The University of the State of New York

REGENTS HIGH SCHOOL EXAMINATION

PHYSICAL SETTING
EARTH SCIENCE

Friday, June 20, 2025 — 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.

Part A

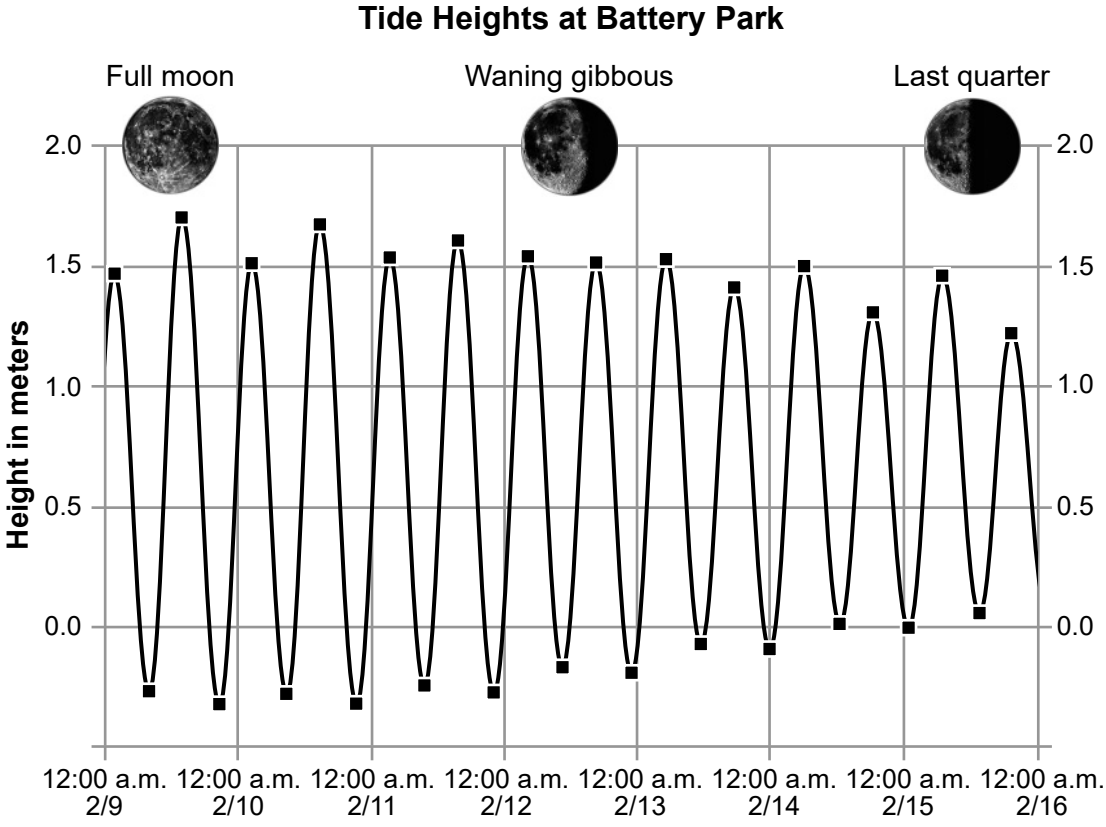
Answer all questions in this part.

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 heliocentric model of the solar system shows the

(1) temperature of the Sun compared to the temperature of the planets
(2) age of the Sun compared to the age of the planets
(3) location of the planets in relation to the Sun
(4) size of the planets in relation to the Sun

2 The graph below shows the ocean tides at Battery Park in New York City from February 9 to February 15, 2020. The phases of the Moon for select dates are shown at the top of the graph.



Compared to tides that occur during other Moon phases, which conclusion about tides that occur during a full moon can be made from the graph?

(1) High tide is lower when there is a full moon.
(2) Low tide is higher when there is a full moon.
(3) The tidal range is greater when there is a full moon.
(4) The tidal range is less when there is a full moon.

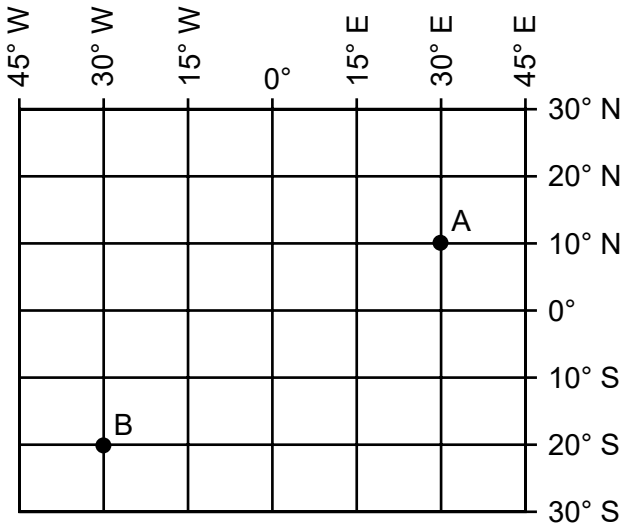
3 Evidence of Earth's rotation on its axis is provided by both the

(1) Doppler effect and El Niño
(2) Doppler effect and the Coriolis effect
(3) Foucault pendulum and El Niño
(4) Foucault pendulum and the Coriolis effect

4 At which New York State location is the observed altitude of Polaris approximately 42°?

(1) Rochester
(2) New York City
(3) Plattsburgh
(4) Binghamton

5 The diagram below represents a portion of Earth's latitude and longitude system. Letters *A* and *B* represent locations on Earth's surface.



When the time at location *A* is 12 noon, what time is it at location *B*?

(1) 8 a.m.
(2) 9 a.m.
(3) 3 p.m.
(4) 4 p.m.

6 Orion is a constellation of stars that is visible in the evening sky in New York State from November through February. Orion is not visible the rest of the year because

(1) Earth rotates on its axis
(2) Earth revolves around the Sun
(3) Orion rotates on its axis
(4) Orion revolves around Earth

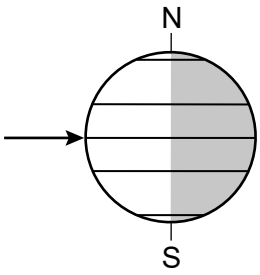
7 The hydrosphere is a relatively thin layer of

(1) solid rock making up approximately 70% of Earth's surface
(2) solid rock making up approximately 30% of Earth's surface
(3) water covering approximately 70% of Earth's surface
(4) water covering approximately 30% of Earth's surface

8 Earth revolves around the Sun at a rate of approximately

(1) 1° per day
(2) 360° per day
(3) 15° per hour
(4) 23.5° per hour

9 The diagram below represents Earth's position relative to the Sun's rays on September 23. The arrow shows the Sun's direct rays striking the equator at solar noon.



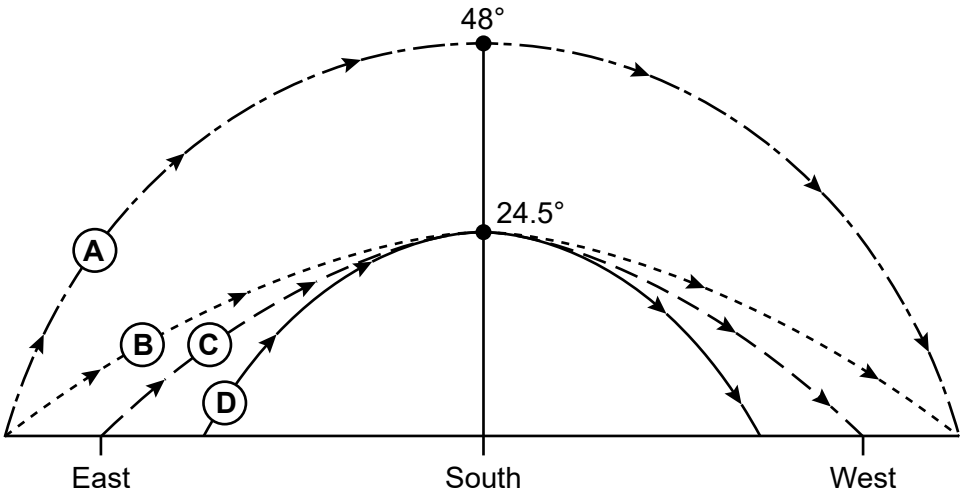
During the next six months, the angle of the Sun's rays striking the equator at solar noon will

(1) decrease only
(2) decrease then increase
(3) increase only
(4) increase then decrease

10 Which type of unsaturated sediment will have the greatest permeability during a rainstorm?

(1) rounded and tightly packed
(2) rounded and loosely packed
(3) flattened and tightly packed
(4) flattened and loosely packed

11 The diagram below represents four different apparent paths of the Sun across the sky at four different locations. The paths are labeled *A*, *B*, *C*, and *D*.



Which line best represents the apparent path of the Sun across the sky on December 21 in New York State?

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

12 Which table correctly indicates the locations of the polar front jet stream and subtropical jet stream near the time of the equinox?

Polar Front Jet Stream	60° North and 60° South
Subtropical Jet Stream	30° North and 30° South

(1)

Polar Front Jet Stream	90° North and 90° South
Subtropical Jet Stream	30° North and 30° South

(3)

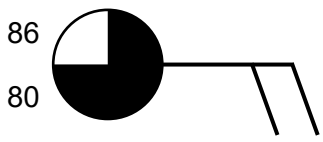
Polar Front Jet Stream	30° North and 30° South
Subtropical Jet Stream	60° North and 60° South

(2)

Polar Front Jet Stream	90° North and 90° South
Subtropical Jet Stream	60° North and 60° South

(4)

13 The station model below represents some weather conditions at Syracuse, New York.



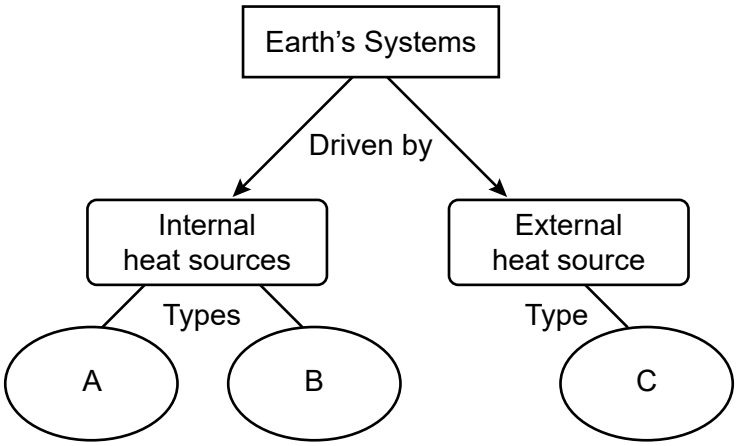
What is the best description of the weather at Syracuse?

(1) hot and dry with winds from the east
(2) hot and humid with winds from the east
(3) hot and humid with winds from the west
(4) hot and dry with winds from the west

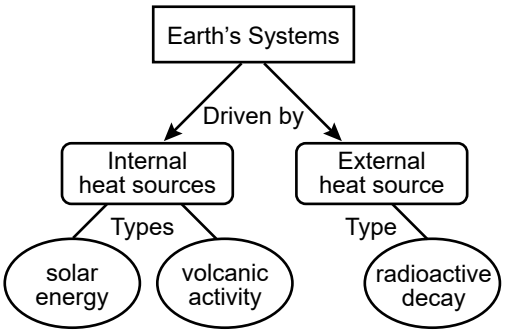
14 Which air mass is characterized by high relative humidity and low air temperature?

(1) maritime polar
(2) maritime tropical
(3) continental polar
(4) continental tropical

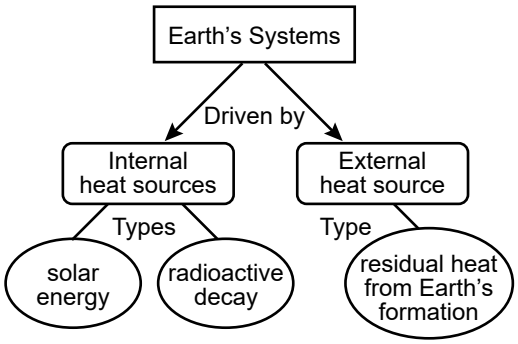
15 The incomplete flow chart below represents heat sources that provide energy for Earth's systems. The types of heat sources, labeled *A*, *B*, and *C*, have been left blank.



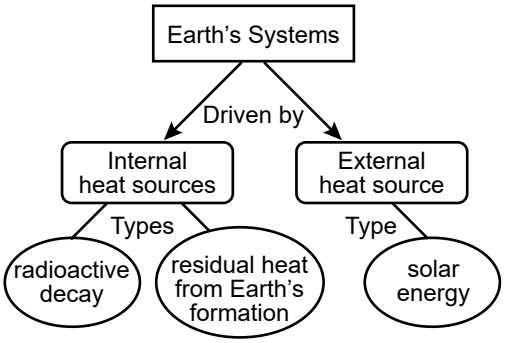
Which flow chart correctly identifies the types of heat sources for *A*, *B*, and *C*?



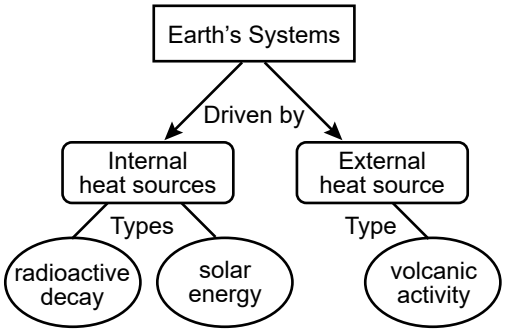
(1)



(3)

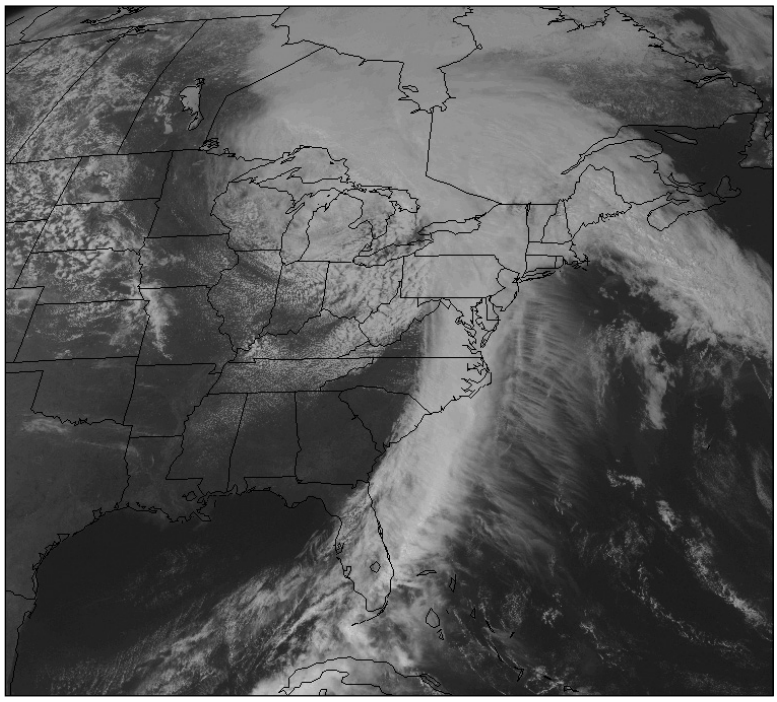


(2)



(4)

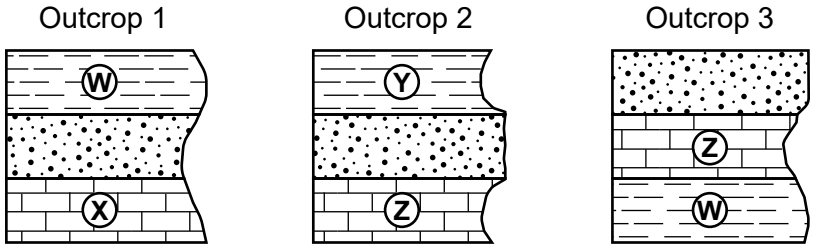
16 A visible satellite image of the eastern United States is shown below. Visible satellite images resemble black and white photographs because clouds reflect sunlight and appear white, while land and water appear in shades of gray or black.



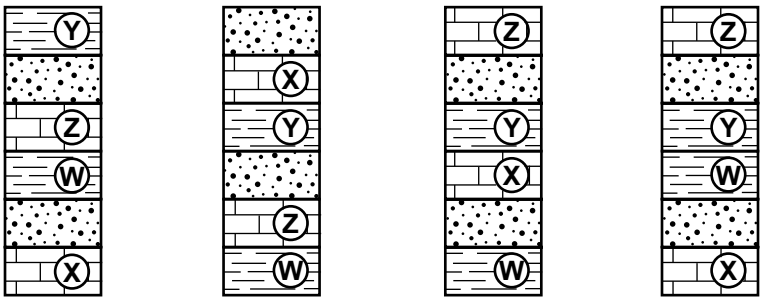
Which weather variable can be most accurately forecast using this satellite image?

(1) air temperature
(2) wind speed
(3) areas of precipitation
(4) type of precipitation

17 The cross sections below show widely separated outcrops labeled 1, 2, and 3. The rock layers have not been overturned. Letters *W*, *X*, *Y*, and *Z* represent fossils in some of the layers.



Which column represents the correct sequence of fossils based on the correlation of the three outcrops?



18 Which land surface absorbs the greatest amount of insolation?

(1) dark color and rough texture
(2) dark color and smooth texture
(3) light color and rough texture
(4) light color and smooth texture

19 During which era of Earth's geologic history did oceanic oxygen begin to enter Earth's atmosphere?

(1) Cenozoic Era
(2) Paleozoic Era
(3) Early Archean Era
(4) Early Proterozoic Era

20 When did humans appear on Earth?

(1) before abundant grazing mammals and after the earliest flowering plants
(2) before the earliest grasses and after large carnivorous mammals
(3) during the same time as mastodonts and mammoths
(4) during the same time as the first forests and ammonoids

21 If a rock contained 200 grams of the radioactive isotope potassium-40 (^{40}K) when it was formed, but now contains only 25 grams of potassium-40 (^{40}K), how many years ago did the rock form?

(1) 1.3×10^9 years
(2) 2.6×10^9 years
(3) 3.9×10^9 years
(4) 5.2×10^9 years

22 The Alleghenian and Acadian orogenies were caused by which geologic process?

(1) deposition of minerals in evaporate basins
(2) original opening of oceans
(3) widespread coastal deposition
(4) collision of landmasses

23 The continents of Africa and South America were inferred to be two separate continents

(1) 59 million years ago
(2) 119 million years ago
(3) 232 million years ago
(4) 359 million years ago

24 Which surface feature was produced by crustal movements at a divergent plate boundary?

(1) San Andreas Fault
(2) Peru-Chile Trench
(3) Southeast Indian Ridge
(4) Tasman Hot Spot

25 Which Earth layer has a density similar to the density of Mercury?

(1) oceanic crust
(2) stiffer mantle
(3) outer core
(4) inner core

26 Which factor is primarily responsible for the development of the stream drainage patterns in New York State?

(1) bedrock age
(2) bedrock structure
(3) types of fossils in the bedrock
(4) amount of fossils in the bedrock

27 Which processes result in the formation of soil?

(1) the compaction and cementation of sediments
(2) the melting and solidification of minerals
(3) biological activity and the weathering of rocks
(4) the addition of heat and pressure to bedrock

28 The table below shows the densities of four mineral samples of equal size and shape transported in a stream.

Mineral	**Density** (g/cm^3)
Olivine	3.5
Garnet	4.0
Quartz	2.7
Pyrite	5.0

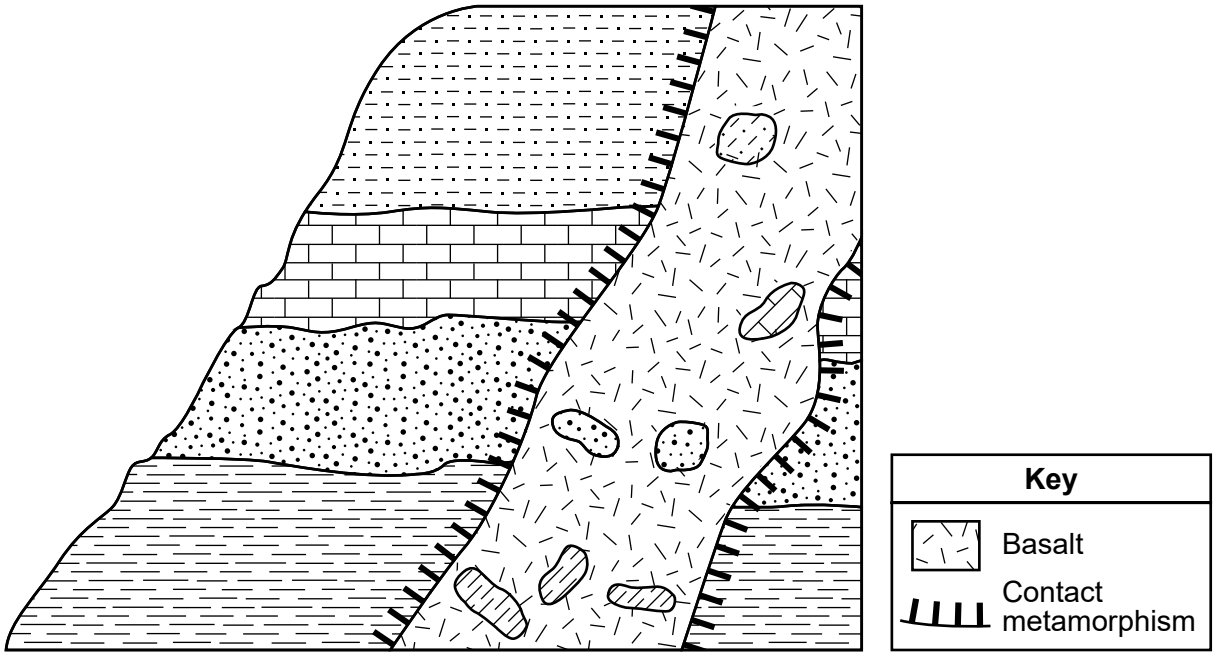
As this stream flows into a lake, which mineral sample would most likely be deposited first?

(1) olivine
(2) garnet
(3) quartz
(4) pyrite

29 Hematite and magnetite are mined as ores because they contain the element

(1) iron
(2) sulfur
(3) aluminum
(4) oxygen

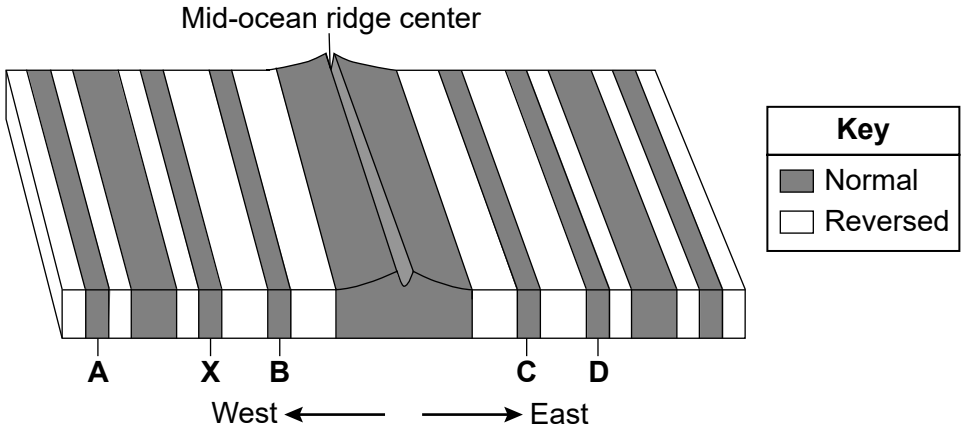
30 The cross section below represents a portion of Earth's crust. The basalt intrusion contains several inclusions.



The relative age of the limestone inclusion is

(1) younger than the basalt and older than the sandstone layer
(2) younger than the basalt and older than the limestone layer
(3) older than the basalt and older than the shale layer
(4) older than the basalt and older than the siltstone layer

31 The block diagram below represents the magnetic orientation of igneous bedrock on the seafloor on the western and eastern sides of a mid-ocean ridge. The letters *A*, *B*, *C*, *D*, and *X* identify locations of specific bands of magnetic orientation.



Which location is the same age as location *X* ?

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

32 The photograph below shows an escarpment feature formed by uplift and erosion.

An escarpment is best described as a

(1) steep, rocky cliff
(2) coastal shoreline
(3) mountain ridge
(4) depositional basin

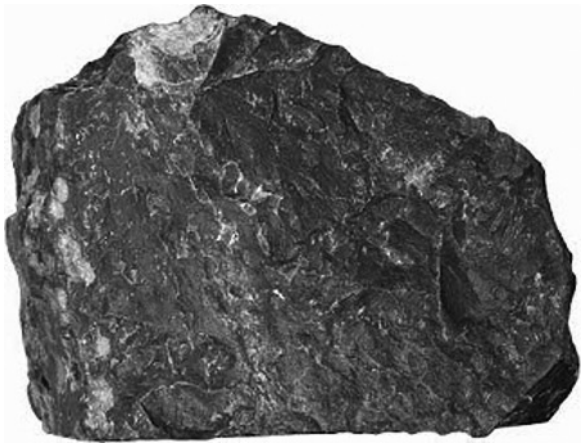
33 The photograph below shows parallel scratches on the surface of a rock.

www.flickr.com

Which erosional agent most likely produced these parallel scratches?

(1) wind
(2) glacier
(3) wave action
(4) running water

34 The picture below shows a sample of the metamorphic rock hornfels.

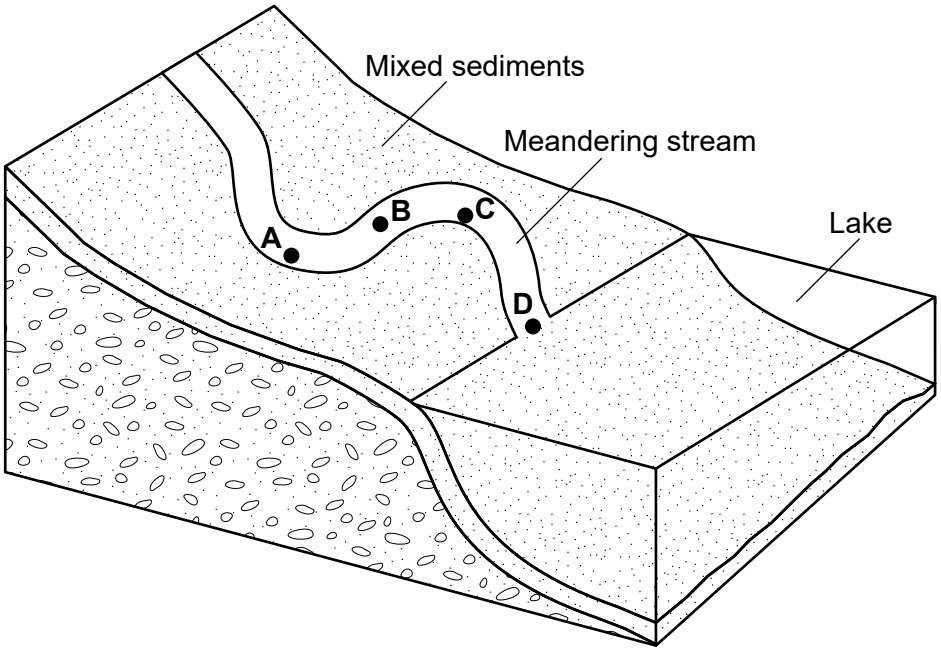


geologylearn.blogspot.com

Hornfels is commonly formed when existing rock is changed due to

(1) regional metamorphism of bituminous coal
(2) contact with rising magma from tectonic activity
(3) foliation from the pressure of overlying rock layers
(4) seismic activity along a fault in Earth's crust

35 The diagram below represents a stream entering a lake. Letters *A*, *B*, *C*, and *D* represent locations in the stream.



At which two locations in the stream will the greatest amount of deposition be occurring?

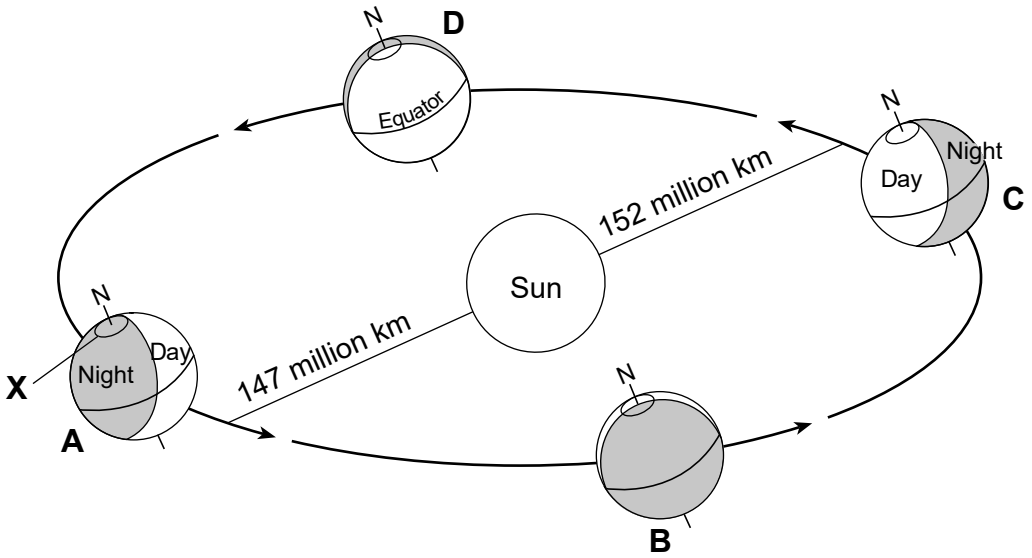
(1) *A* and *B*
(2) *B* and *C*
(3) *C* and *D*
(4) *D* and *A*

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 38 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) and perihelion (Earth's closest position to the Sun). Arrows indicate directions of movement. Letter *X* represents a latitude on Earth.



(Not drawn to scale)

36 Approximately how many days does Earth take to move from position *A* to position *D*?

(1) 91 days
(2) 183 days
(3) 274 days
(4) 365 days

37 Which latitude on Earth is represented by location *X*?

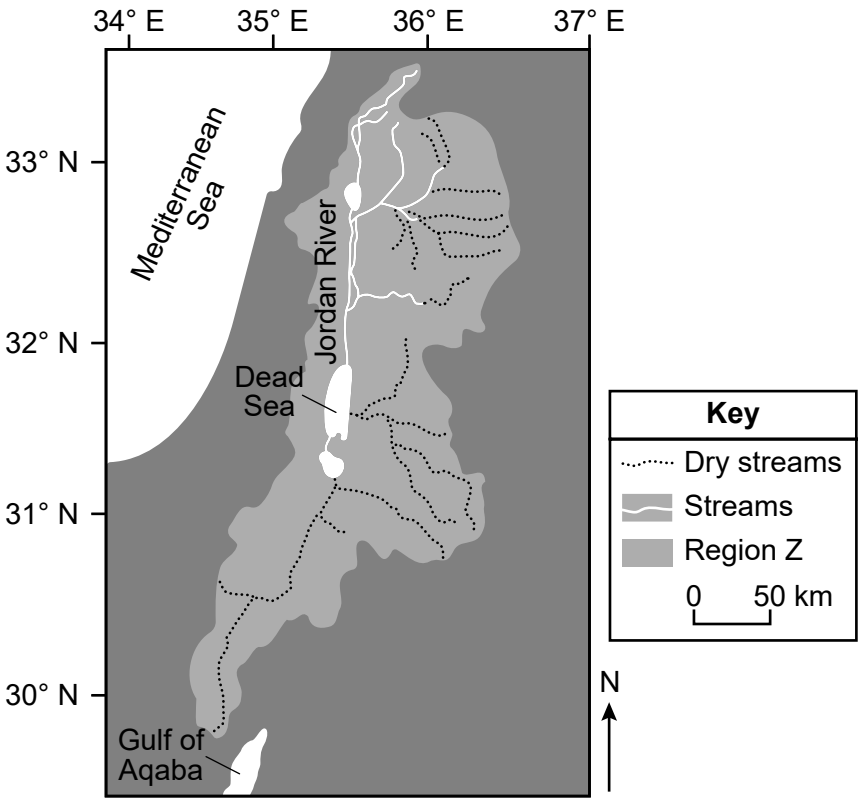
(1) Tropic of Cancer
(2) Tropic of Capricorn
(3) Arctic Circle
(4) Antarctic Circle

38 If the tilt of Earth's axis were increased from 23.5° to 31°, the Northern Hemisphere summer would become

(1) warmer and winter would become warmer
(2) warmer and winter would become cooler
(3) cooler and winter would become cooler
(4) cooler and winter would become warmer

Base your answers to questions 39 and 40 on the passage and map below and on your knowledge of Earth science. The map shows the Dead Sea. The lightly shaded area, Region Z, represents all the rivers, streams, and tributaries that flow into the Dead Sea.

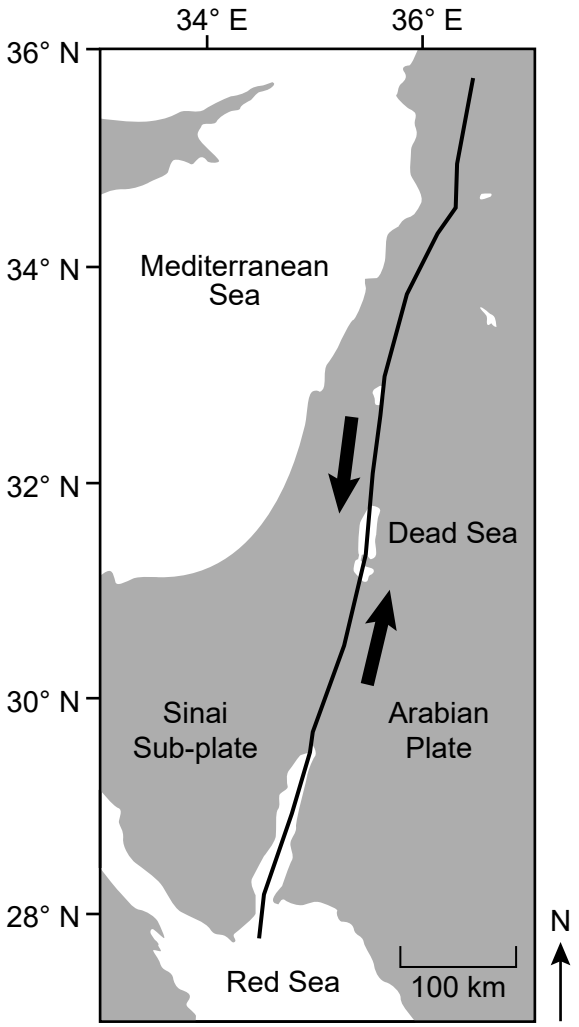
The Dead Sea is the lowest point on the surface of Earth. The Dead Sea is actually a lake which lies at the mouth of the Jordan River. The water is famous because it is 10 times saltier than the ocean. Small amounts of dissolved minerals are transported into the Dead Sea. Over thousands of years these minerals are left behind when the water evaporates. Recent demand for water in the region has increased significantly and has led to a decrease in the water level of the Dead Sea. In 1896, the lake surface was 1296 feet below sea level, and in 2016 the lake surface was 1412 feet below sea level. The fresh water of the Jordan River must now flow farther to reach the Dead Sea. As it flows, the fresh water of the river dissolves the layers of minerals previously deposited around the Dead Sea.



39 Which mineral is most commonly found on the shores of the Dead Sea?

(1) halite
(2) hematite
(3) quartz
(4) talc

40 The map below shows the tectonic plate boundary located at the Dead Sea.

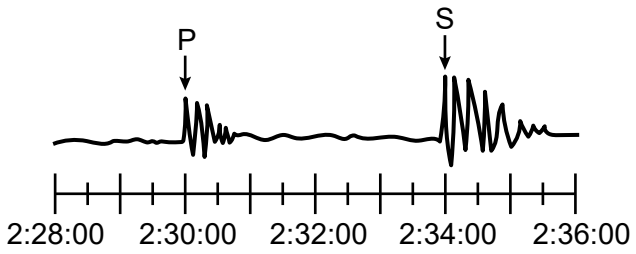


Which type of tectonic plate boundary is found where the Dead Sea is located?

(1) complex or uncertain
(2) convergent
(3) divergent
(4) transform

Base your answers to questions 41 and 42 on the seismogram and data table below and on your knowledge of Earth science. The seismogram and data table have information about an earthquake recorded at a seismic monitoring station.

Seismogram

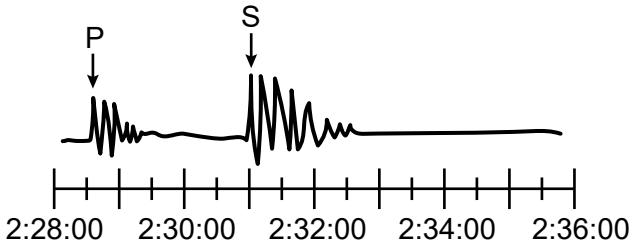


Earthquake Data Collected	
Time of P-wave arrival	02:30:00 p.m.
Time of S-wave arrival	02:34:00 p.m.
Distance to epicenter	2600 km

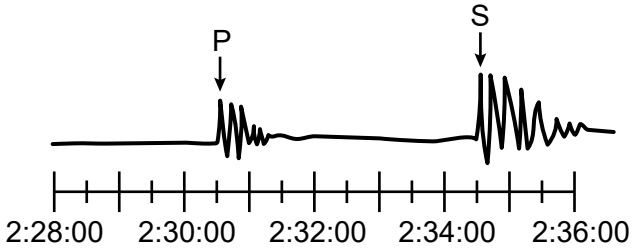
41 At what time did this earthquake occur?

(1) 02:21:00 p.m.
(2) 02:25:00 p.m.
(3) 02:26:00 p.m.
(4) 02:35:00 p.m.

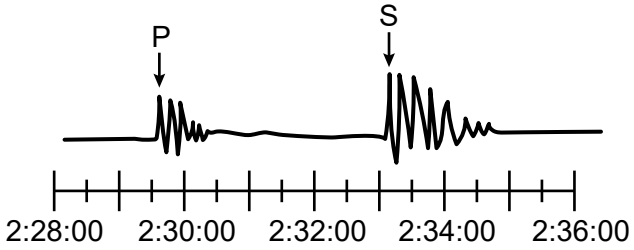
42 Which seismogram was recorded closest to the epicenter of this earthquake?



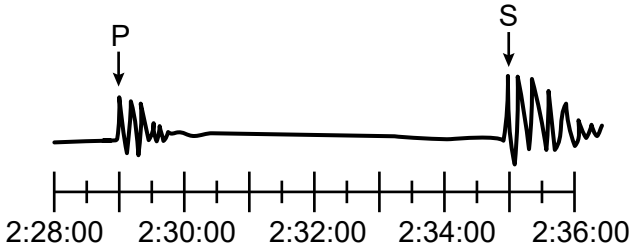
(1)



(3)

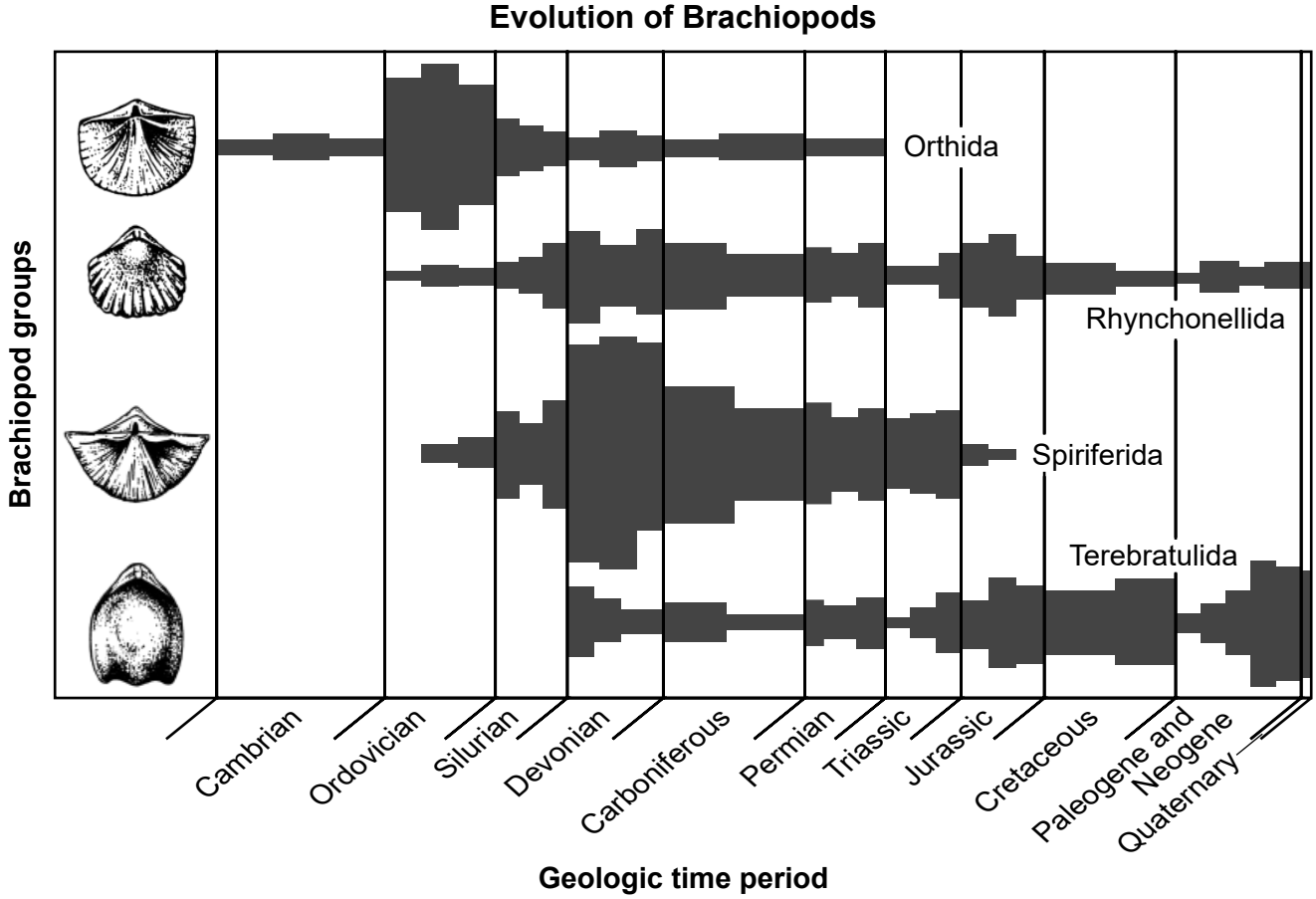


(2)



(4)

Base your answers to questions 43 through 45 on the graph below and on your knowledge of Earth science. The graph indicates changes in the number of four different brachiopod groups from the early Cambrian to the present. A picture of a representative member of each group is shown in the left column. The width of each bar indicates the relative number of different types of brachiopods within each group.



43 What does this graph indicate about the history of the Orthida group?

(1) They existed for the longest period of geologic time.
(2) Some types in the Orthida group still exist today.
(3) More types lived during the Silurian period than the Ordovician period.
(4) Many types have lived in the past and are now extinct.

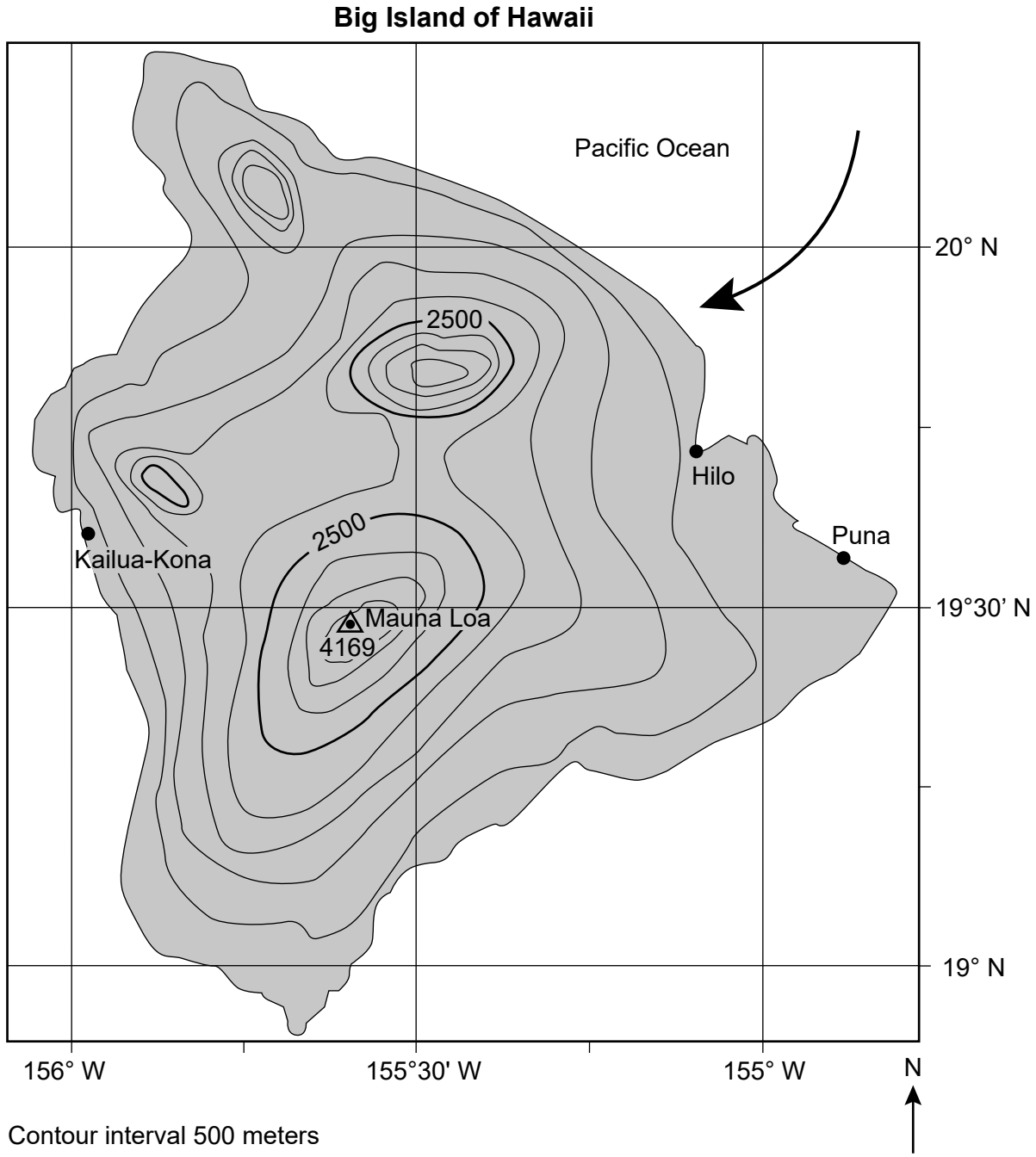
44 Which two other fossil groups found in New York State first appeared on Earth during the same geologic time period that the Orthida Brachiopod group first appeared?

(1) trilobites and ammonoids
(2) trilobites and gastropods
(3) eurypterids and ammonoids
(4) eurypterids and gastropods

45 Which brachiopod group had the greatest number of types of organisms existing at the time of existence of the New York State index fossil *Platyceras*?

(1) Orthida
(2) Rhynchonellida
(3) Spiriferida
(4) Terebratulida

Base your answers to questions 46 through 48 on the contour map below and on your knowledge of Earth science. The contour map shows elevations in meters on the Big Island of Hawaii. The elevation of Mauna Loa, a volcanic mountain, is indicated. The large arrow represents the direction of prevailing winds.



46 Compared to Kailua-Kona, the amount of rainfall received at Hilo is

(1) less due to Hilo being at a lower longitude
(2) less due to Hilo receiving winds containing less moisture
(3) greater due to Hilo being at a lower longitude
(4) greater due to Hilo receiving winds containing more moisture

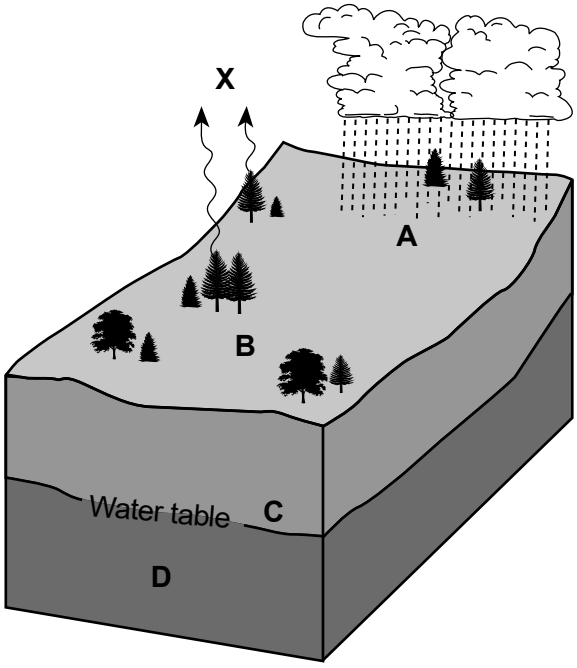
47 After visible light is absorbed by the land surfaces of the Big Island of Hawaii, which form of long-wave electromagnetic energy is radiated?

(1) x rays
(2) ultraviolet
(3) infrared
(4) gamma rays

48 Compared to Puna, Mauna Loa has a cooler climate because Mauna Loa

(1) is farther from the ocean
(2) has a higher elevation
(3) is located in a different wind belt
(4) receives less insolation

Base your answers to questions 49 and 50 on the block diagram below and on your knowledge of Earth science. The block diagram shows a portion of Earth's crust and some processes within the water cycle. Letters *A*, *B*, *C*, and *D* represent different areas and zones on the diagram. Letter *X* represents a water cycle process.



Key	
A	Area of runoff
B	Area of infiltration
C	Zone of capillary action
D	Zone of saturation

49 An increase in yearly precipitation would most likely cause

(1) decreased erosion of soil at area *A*
(2) decreased infiltration of rainwater at area *B*
(3) increased groundwater in zone *C*, lowering the water table
(4) increased groundwater in zone *D*, raising the water table

50 Process *X*, labeled in the diagram, represents

(1) transpiration
(2) precipitation
(3) condensation
(4) radiation

Part B–2

Answer all questions in this part.

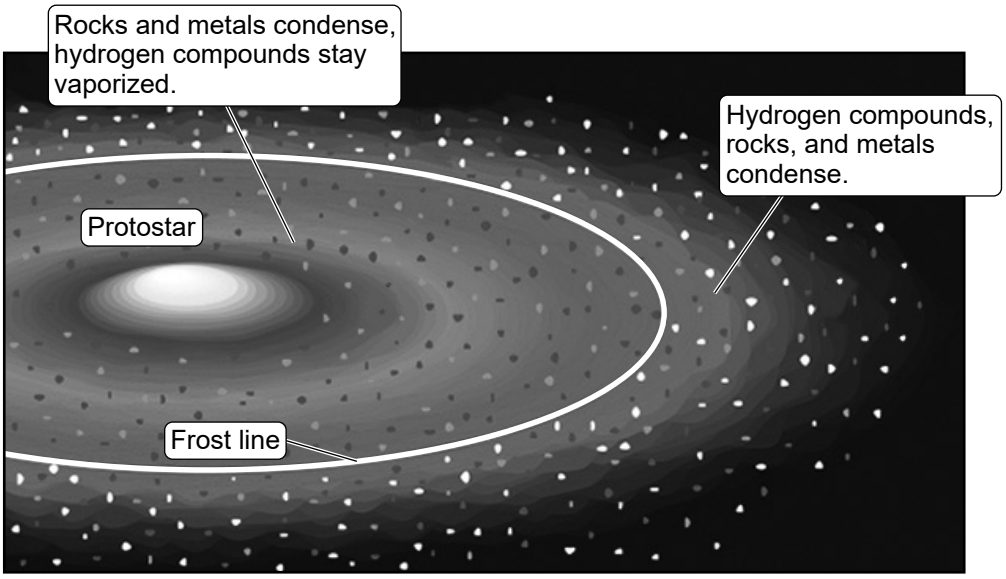
Directions (51–65): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Earth Science*.

Base your answers to questions 51 through 54 on the passage and diagram below and on your knowledge of Earth science. The diagram represents a developing system indicating the frost line around a protostar (early star).

Planet Formation and the Frost Line

Our solar system formed in an immense region of gases with metallic and rocky debris known as a nebula. The frost line marks a temperature boundary between the higher temperature region near the protostar (which later became the Sun) and the lower temperature outer region. Temperature determined the types of materials that began to form the early planets.

Inside the frost line, closer to the protostar, metallic and rocky materials condensed and solidified into rocky planets. Outside of the frost line, lighter elements and gases condensed, with some solidifying, making the size of these planets larger. The four planets that formed inside of the frost line are referred to as the terrestrial planets. The four planets that formed outside of the frost line are referred to as the Jovian planets.



(Not drawn to scale)

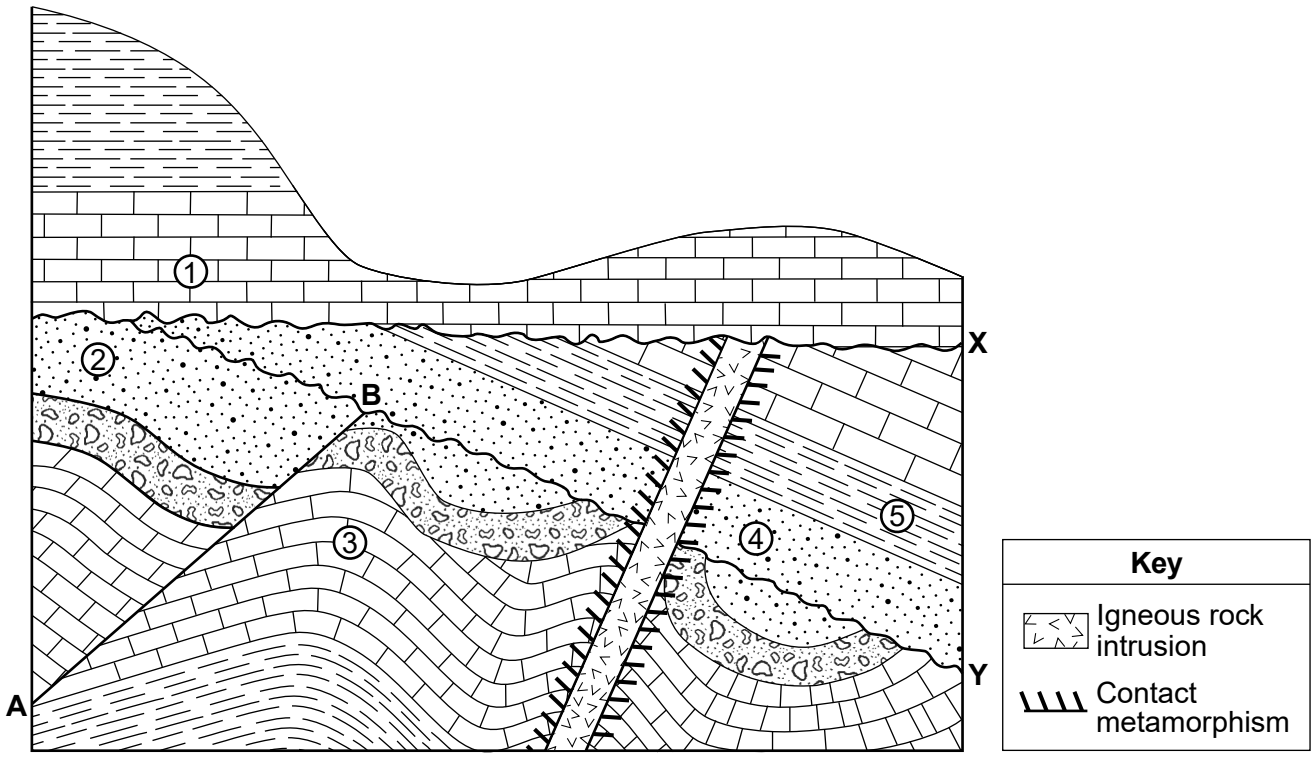
51 On the graph *in your answer booklet*, draw a line to represent the general relationship between the distance from a protostar and the temperature in the nebula. [1]

52 Identify the names of the two planets that formed directly on either side of the frost line. [1]

53 Since the origin of our Solar System, the Sun has evolved from a protostar to its current early stage position in the main sequence. Identify the star classification of our Sun when it will be in the late stage of its development. [1]

54 Identify the nuclear process that produces energy when a protostar becomes a star like our Sun. [1]

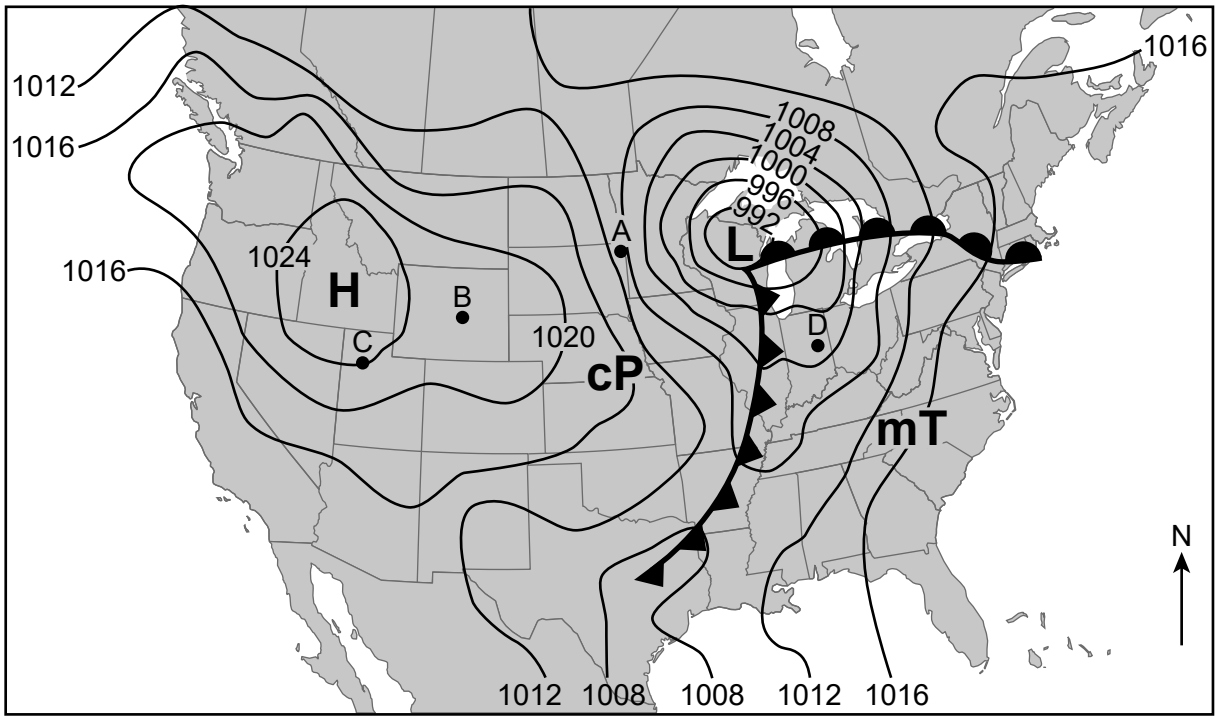
Base your answers to questions 55 and 56 on the geologic cross section below and on your knowledge of Earth science. Numbers 1 through 5 represent rock units. Line *AB* represents a fault. Lines *X* and *Y* represent unconformities. The rock layers have not been overturned.



55 Identify *one* metamorphic rock that was most likely formed in the zone of contact metamorphism between rock unit 4 and the intrusion. [1]

56 Describe one piece of evidence shown in the cross section that indicates layer 3 has undergone crustal movement. [1]

Base your answers to questions 57 through 59 on the weather map below and on your knowledge of Earth science. The weather map shows a high-pressure system (**H**) and low-pressure system (**L**). Two different fronts associated with this low-pressure system are indicated. Isobars are in millibars (mb). Points *A* through *D* represent locations on Earth's surface.



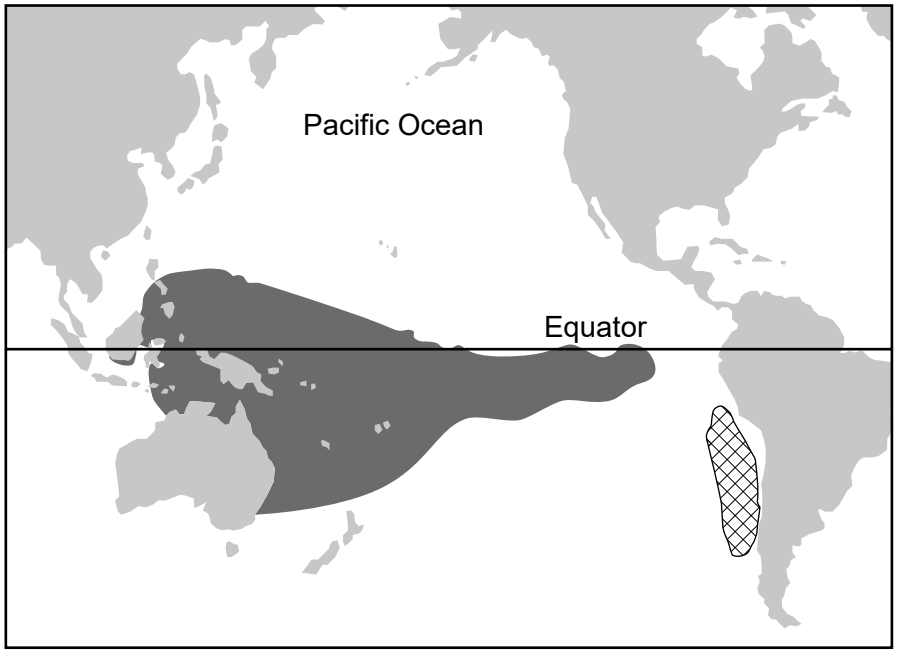
57 Identify the lettered location on the map, *A*, *B*, *C*, or *D*, that has the greatest wind speed. Describe *one* piece of evidence on the map that indicates that this location has the greatest wind speed. [1]

58 *In your answer booklet*, circle one characteristic in each row that describes the general surface wind circulation pattern associated with the high-pressure system. [1]

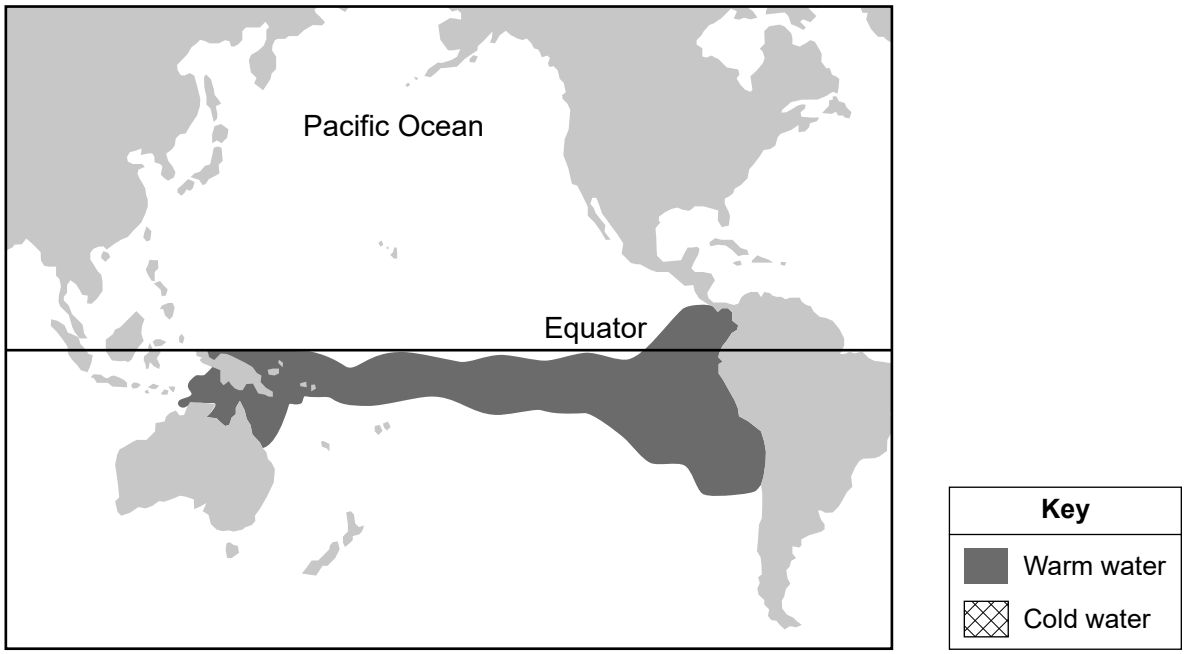
59 Convert the air pressure of the lowest isobar shown on the map from millibars (mb) to inches of mercury (in of Hg). [1]

Base your answers to questions 60 and 61 on the maps below and on your knowledge of Earth science. Map *A* shows warm and cold areas of the Pacific Ocean under normal conditions. Map *B* shows areas of warmer water under El Niño conditions.

Map A: Normal Conditions



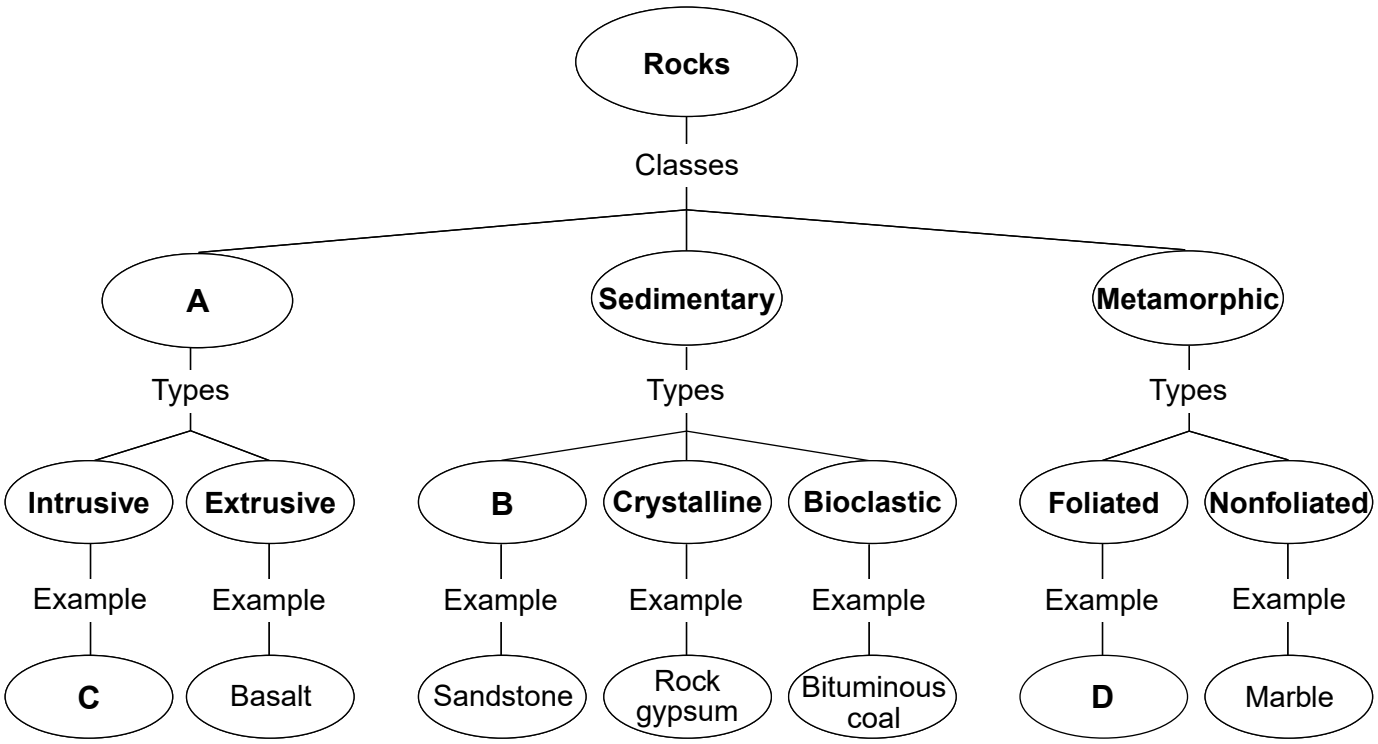
Map B: El Niño Conditions



60 Identify the *two* warm ocean currents that transport water from South America to Australia under normal conditions. [1]

61 Describe how the relative air temperature and relative amount of precipitation along the west coast of South America are affected by an El Niño event. [1]

Base your answers to questions 62 through 65 on the flowchart below and on your knowledge of Earth science. The flow chart shows a scheme for classifying rocks. The circled letters *A*, *B*, *C*, and *D* indicate parts of the chart that have not been completed.



62 Identify *two* processes necessary to produce the class of rock represented by letter *A*. [1]

63 State the type of sedimentary rock represented by letter *B*. [1]

64 Compared to the crystal size and cooling rate of the basalt, describe how the crystal size and cooling rate of rock *C* is different. [1]

65 Rock *D* is composed of coarse-grained mineral crystals that are arranged in light- and dark-colored distorted bands. State the name of rock *D*. [1]

Part C

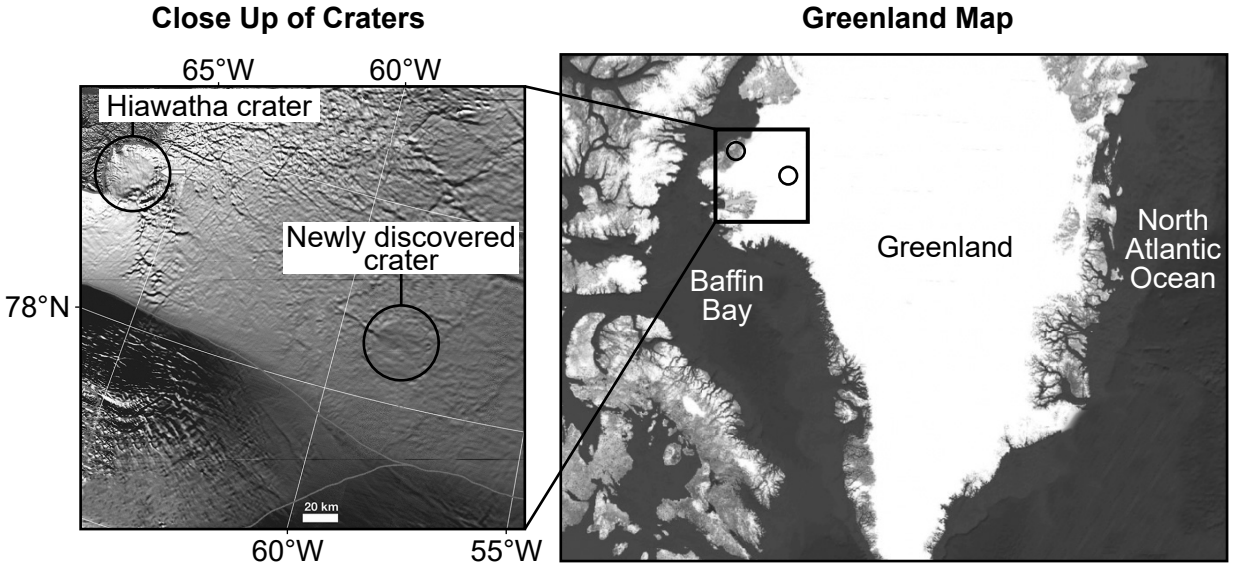
Answer all questions in this part.

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 map and passage below and on your knowledge of Earth science. The map shows the location of Hiawatha crater and a second newly discovered crater in Greenland. These two craters are found under the glacial ice.

Second Crater Found in Greenland

In 2019, NASA scientists discovered a second crater under Greenland's ice sheet. Using satellite images of the topography beneath the one-mile thick ice sheet, a visible, circular depression was identified. By studying magnetic and gravitational fields, scientists determined a possible cause. If the crater were formed from a volcano, irregular magnetic patterns would be found in the rocks, but none were found. So scientists infer that this crater formed from an impact event. It was determined that the undisturbed ice covering the crater was 79,000 years old, so the impact event must have occurred prior to this time.



66 Explain why this crater was most likely caused by an impact event instead of a past volcanic eruption. [1]

67 Identify *one* possible effect on Earth of a major impact event. [1]

68 Identify *one* climate factor that most likely contributes to the cold climate of Greenland. [1]

Base your answers to questions 69 through 72 on the topographic map *in your answer booklet*, which shows elevations in meters, and on your knowledge of Earth science. The 700-meter and 800-meter contour lines in the western portion of this map are incomplete. Line *AB* is a reference line on the map.

69 On the map *in your answer booklet*, complete the 700-meter and 800-meter contour lines in the western portion of this map. Extend the lines to the edge of the map. [1]

70 On the grid *in your answer booklet*, construct a topographic profile along line *AB* by plotting the elevation of *all seven* contour lines that cross line *AB*. Elevations for points *A* and *B* have been plotted. Connect *all nine plots* from *A* to *B*. [1]

71 Identify *one* possible elevation for the surface of Dunn Pond. [1]

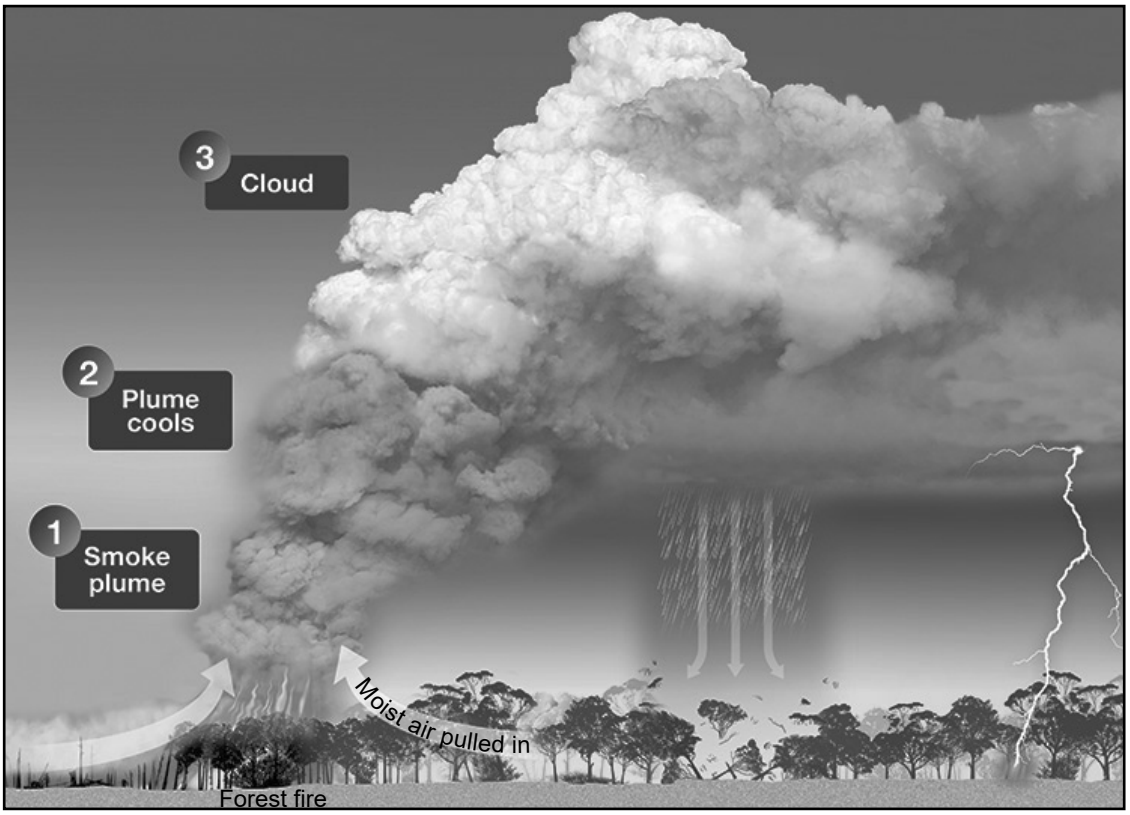
72 On the table *in your answer booklet*, place an **X** in one box in each row to indicate whether each creek is flowing into or out of Dunn Pond. [1]

Base your answers to questions 73 through 76 on the passage and diagram below and on your knowledge of Earth science. The diagram represents the formation of a pyrocumulonimbus cloud. Some parts of the diagram are labeled.

Pyrocumulonimbus Clouds

Normally, cool air keeps smoke from rising high in the atmosphere. However, very intense fires can create giant storm clouds, called pyrocumulonimbus clouds, that can reach heights up to 23 kilometers. Smoke and soot (black carbon particles) can remain at these heights for months and sometimes damage the ozone layer.

Pyrocumulonimbus Cloud Formation



73 On the diagram *in your answer booklet*, place an **X** on the scale to represent the height in kilometers (km) pyrocumulonimbus clouds can reach. Identify the name of the temperature zone of the atmosphere that corresponds to this height. [1]

74 A damaged ozone layer can have harmful effects on organisms on Earth. Explain how the ozone layer reduces these harmful effects. [1]

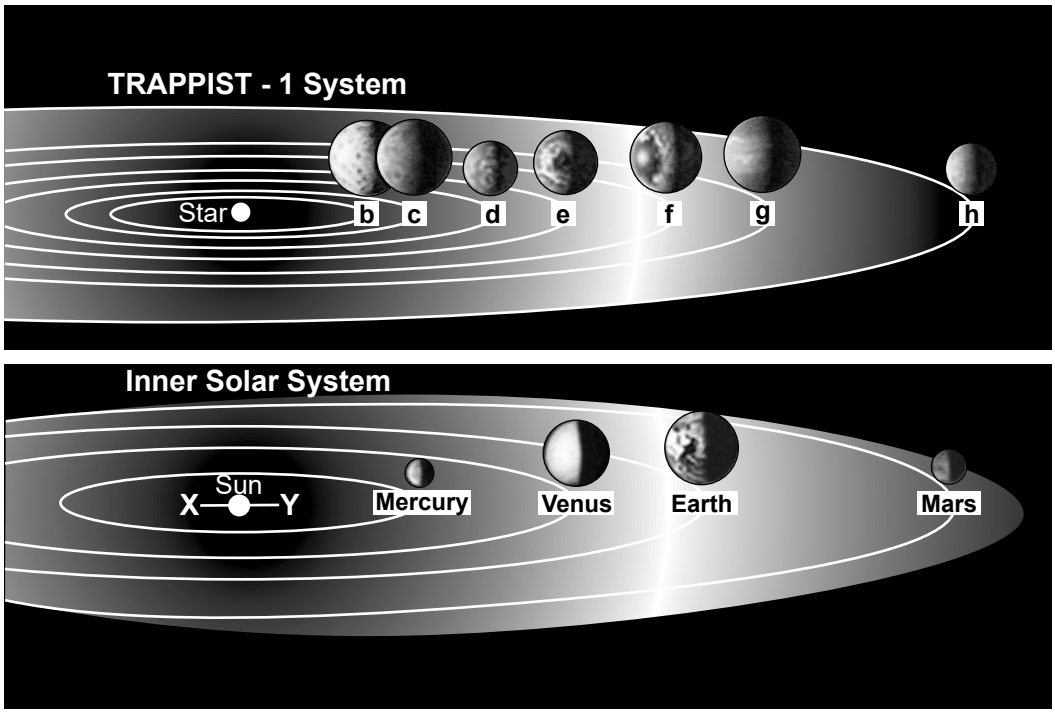
75 Explain how an increase in smoke and soot in the atmosphere normally decreases temperatures on Earth's surface. [1]

76 As the wildfires burn, large amounts of carbon dioxide are released into the atmosphere. Explain why scientists are concerned with the release of carbon dioxide into Earth's atmosphere. [1]

Base your answers to questions 77 through 80 on the passage and diagram below and on your knowledge of Earth science. The diagram compares the sizes of seven exoplanets located outside of our solar system in the Trappist-1 system to the sizes of the first four planets in our solar system. Line *XY* is drawn to indicate the size of the Trappist-1 system if it were located within our own solar system and centered around our Sun.

Trappist-1 Exoplanets

NASA's Spitzer Space Telescope has revealed seven Earth-sized exoplanets (identified by letters b through h) revolving around a star named Trappist-1. Located about 235 trillion miles from Earth, this system of exoplanets is within our galaxy and can be observed in the constellation Aquarius. Trappist-1 is classified as a dwarf star, with a size that is approximately one-tenth the size of the Sun, and with a surface temperature of approximately 2500 K. All seven of the Trappist-1 planetary orbits are much closer to their host star than Mercury is to our Sun.



(Size of Sun and star not drawn to scale)

www.spitzer.caltech.edu

77 State the color of the star Trappist-1. [1]

78 Identify the planet in our solar system that has a diameter closest to the estimated diameter of the star Trappist-1. [1]

79 Exoplanet Trappist-1g orbits its star in 12.35 days. Explain why this exoplanet orbits its star in less time than it takes Mercury to orbit our Sun. [1]

80 These exoplanets were discovered because the light from Trappist-1 was observed to dim slightly every time an orbiting planet transited (passed in front of) the star. Identify *one* natural celestial object in our solar system that transits our Sun and temporarily reduces the light that reaches Earth. [1]

Base your answers to questions 81 through 83 on the photographs below and on your knowledge of Earth science. The photographs show samples of sandstone, labeled *A* through *D*.

(A) (B) (C) (D)

(Not drawn to scale)

81 Identify the letter of the sandstone sample that most likely underwent the greatest amount of erosion by a stream and identify evidence shown in the photographs that supports this choice. [1]

82 Sandstone sample *C* is 2.0 centimeters in diameter. Determine the minimum stream velocity needed to transport this rock sample. [1]

83 Identify the complete range of grain sizes that could be found in each of these rock samples. [1]

Base your answers to questions 84 and 85 on the data table and Saffir-Simpson Hurricane Scale below, on the map *in your answer booklet*, and on your knowledge of Earth science. The data table shows latitude and longitude locations of the center of Hurricane Dorian, and the maximum sustained wind speed in miles per hour (mph), each day from August 24 to September 7, 2019. The Saffir-Simpson Hurricane Scale shows the wind speeds associated with each storm category. The map *in your answer booklet* shows the location of the hurricane from August 24, 2019 through August 31, 2019.

Date	**Location**		**Maximum sustained wind speed** (mph)
	Latitude	Longitude	
Aug. 24, 2019	10.7°N	49.1°W	40
Aug. 25, 2019	11.5°N	54.2°W	50
Aug. 26, 2019	12.7°N	58.8°W	60
Aug. 27, 2019	15.3°N	62.5°W	50
Aug. 28, 2019	18.8°N	65.5°W	80
Aug. 29, 2019	22.5°N	67.7°W	85
Aug. 30, 2019	25.0°N	70.7°W	115
Aug. 31, 2019	26.2°N	74.4°W	150
Sept. 1, 2019	26.6°N	77.3°W	185
Sept. 2, 2019	26.8°N	78.4°W	145
Sept. 3, 2019	27.7°N	78.7°W	110
Sept. 4, 2019	30.6°N	79.8°W	110
Sept. 5, 2019	33.1°N	78.5°W	105
Sept. 6, 2019	36.9°N	72.7°W	90
Sept. 7, 2019	43.9°N	63.9°W	100

Saffir–Simpson Hurricane Scale

Classification		**Wind Speed** (mph)
Tropical Depression		0-38
Tropical Storm		39-73
Hurricane	Category 1	74-95
	Category 2	96-110
	Category 3	111-130
	Category 4	131-155
	Category 5	>156

84 On the map *in your answer booklet*, complete the path of Hurricane Dorian by plotting the location of the storm center for September 1 through September 7. Draw a line to connect *all seven* of these plots to the August 31 plot to complete the path. [1]

85 Use the Saffir-Simpson scale to identify the two dates when Hurricane Dorian changed from a category 4 hurricane to a category 5 hurricane. [1]

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