SCIENCE TEST

35 Minutes—40 Questions

JOL

Science Lesson 2

DIRECTIONS: There are seven passages in this test. Each passage is followed by several questions. After reading a passage, choose the best answer to each question and fill in the corresponding oval on your answer document. You may refer to the passages as often as necessary.

You are NOT permitted to use a calculator on this test.

Passage I

Students debate 4 hypotheses regarding the Moon's origin, based on the following observations.

Observations

Observation 1 – Earth and the Moon have the same proportions of various oxygen *isotopes* (forms of oxygen).

Observation 2 – The same minerals that compose terrestrial lavas are also found in lunar lava specimens.

Observation 3 – The Moon contains little or no water.

Observation 4 – Earth contains a much higher percentage of iron than does the Moon.

Observation 5 – Fossil records show that the length of Earth's day used to be shorter.

Observation 6 – Collisions between Mars and other objects have resulted in the ejection of material from Mars's surface. Some of the ejected material has reached Earth.

Hypothesis 1

All of the material that formed the Moon came from Earth. The rate of Earth's spin on its axis was high enough at one time to eject material from Earth's surface. This material was unable to escape Earth's gravity and went into orbit around Earth, forming the Moon.

Hypothesis 2

The material that composes the Moon came mostly from Earth's surface. A large object from another part of the solar system collided with Earth and threw the surface material into orbit around Earth. Some of the differences in composition between Earth and the Moon might be accounted for by the composition of matter from the large object.

Hypothesis 3

The Moon was never a part of Earth, because Earth's and the Moon's chemical compositions have too few similarities. The Moon and Earth probably formed within the same cloud of gas and dust, when large clumps of gas and dust in the cloud gravitationally attracted additional materials from the cloud. (The collapse of clouds of gas and dust also results in the formation of stars.)

Hypothesis 4

The Moon most likely came from somewhere in the solar system far from Earth. As the Moon approached Earth, it was attracted more strongly by Earth's gravitational field. Although the Moon speeded up as it approached Earth, it was not moving fast enough as it passed Earth to escape Earth's gravity. Consequently, it entered into orbit around Earth.

1. According to Hypothesis 2, the origin of most of the matter composing the Moon was most likely which of the following objects?

   A. A star far from the Sun
   B. Earth
   C. Mars
   D. The Sun

2. Supporters of Hypothesis 1 would most likely agree that at the time the Moon formed, the rotation rate of Earth on its axis was:

   F. fewer than 1 rotation per year.
   G. 100 rotations per year.
   H. 365 rotations per year.
   J. many more than 365 rotations per year.

3. Suppose that supporters of Hypothesis 2 suggested that the Moon contained a significant amount of water when it was first formed. Which of the following statements about the Moon's water content would be most consistent with their suggestion?

   A. The Moon's water content decreased after the Moon was formed.
   B. The Moon's water content increased rapidly after the Moon was formed.
   C. The Moon's water content increased slowly after the Moon was formed.
   D. The Moon's water content was constant after the Moon was formed.

4. Hypothesis 3 includes the assertion that Earth and the Moon probably formed from the same cloud of gas and dust, most likely to explain which of the following pairs of observations?

   F. Observations 1 and 2
   G. Observations 2 and 3
   H. Observations 2 and 4
   J. Observations 3 and 4

5. The 4 hypotheses discuss 4 possible mechanisms for the Moon's formation. The 4 mechanisms all depend the most on which of the following influences?

   A. Gravity
   B. Earth's rotation
   C. The Moon's rotation
   D. Volcanic action

6. Consider the oxygen isotopes ^{16}O and ^{18}O. If, on Earth, the ratio of ^{16}O to ^{18}O is approximately 500:1, based on the information in Observations 1–6 the ratio of these isotopes on the Moon would most likely be:

   F. 1:1.
   G. 50:1.
   H. 100:1.
   J. 500:1.

7. Which of the following assumptions regarding the Moon's origin is implicit in Hypothesis 1 ?

   A. The Moon is older than Earth.
   B. The Moon is younger than Earth.
   C. The Moon still has active volcanoes.
   D. The Moon's surface composition is identical to that of Earth's core.

Passage II

Large cities have their own climate that differs from the climate in adjacent suburban and rural areas. A scientist performed the following studies to learn more about an urban climate.

Study 1

Air temperatures, in degrees Celsius (°C), were recorded hourly over a 24-hour period at 3 sites: the center of a large city (the urban site), an adjacent suburban site, and a nearby rural site. This was done on 30 consecutive days during summer and 30 consecutive days during winter. Each hourly temperature was averaged over the given season. The results are in Figure 1.

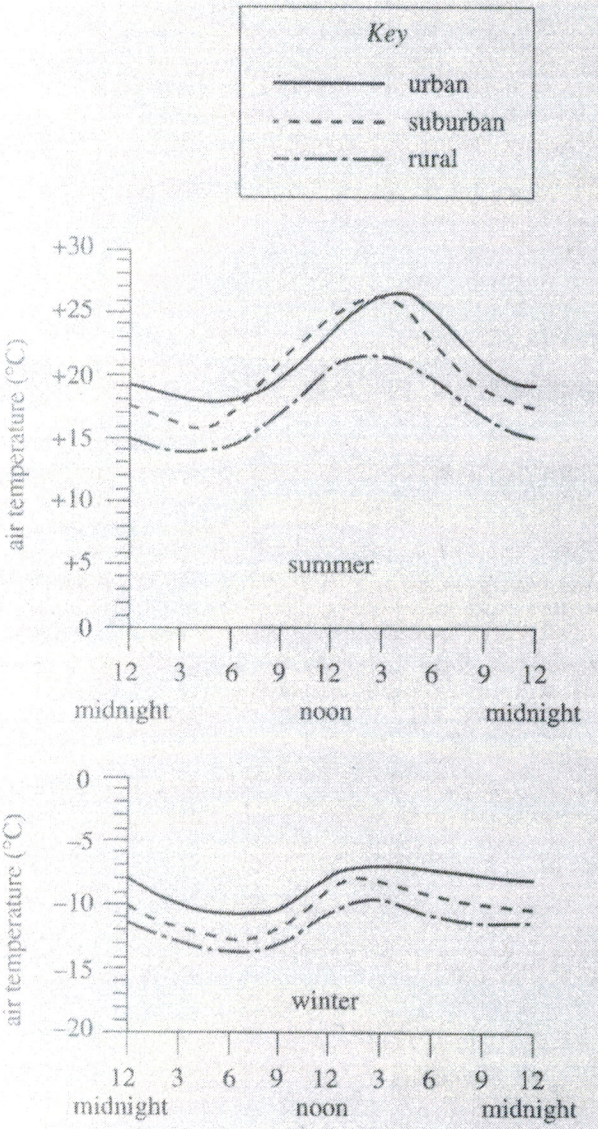


Figure 1

Study 2

A site in the city was selected where a large concrete parking lot was located next to a large grassy area. After the parking lot and grassy area had been exposed to full sunlight for 8 hours, air temperature readings were taken at the surface every 20 meters (m) across the concrete and grass, starting at the center of the parking lot. The results are in Figure 2.

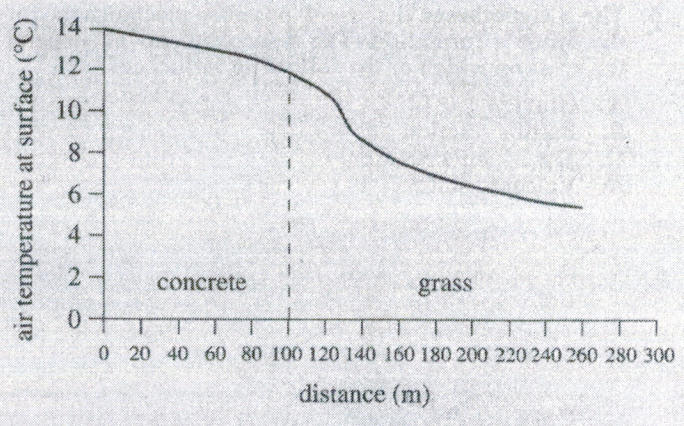


Figure 2

Study 3

Weather instruments were used to measure the wind velocity on 30 days at various altitudes above the 3 sites used in Study 1. The wind velocities, in kilometers per hour (km/hr), were used to generate the wind profiles shown in Figure 3.

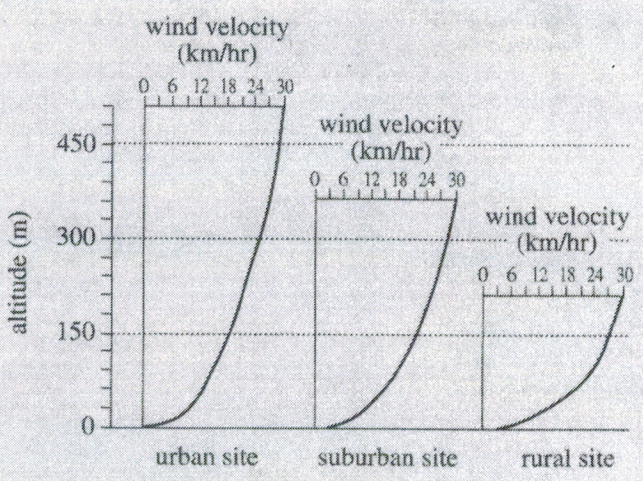


Figure 3

Figures adapted from W. M. Marsh, *Earthscape: A Physical Geography*. ©1987 by John Wiley and Sons, Inc.

Study 4

The scientist kept track of the amount of cloud cover and precipitation daily for 3 years in the city and the rural area. It was found that the city had 10% more cloudy or hazy days and 10% more precipitation than the rural area. Air quality measurements revealed that the city air contained 10 times more dust particles than rural air.

8. According to Study 1, during which of the following time periods does the suburban site always have a higher temperature than the urban site on a summer day?

   F. Between 3 A.M. and 9 A.M.
   G. Between 5 A.M. and 9 A.M.
   H. Between 8 A.M. and 2 P.M.
   J. Between 12 noon and 6 P.M.

9. It is known that water vapor needs solid "nuclei" for it to condense into water droplets and form clouds. According to Study 4, which of the following is the best explanation why the urban area had 10% more rain than the rural area?

   A. Wind velocity is much higher in the city than at the rural site.
   B. The urban area has more dust particles that become nuclei for water droplets.
   C. Fewer clouds form over urban areas compared to rural sites.
   D. Only dust particles can be nuclei for water vapor condensation.

10. Based on the results of Study 3, which of the following generalizations could be made about wind velocities in the 3 study areas?

    F. Urban areas have the highest wind velocity at altitudes below 150 m.
    G. Suburban areas have the highest wind velocity at altitudes below 150 m.
    H. Rural areas have the highest wind velocity at altitudes below 150 m.
    J. Urban areas have the same wind velocity as suburban areas at any given altitude.

11. If Study 1 produced results typical of any rural site, which of the following generalizations could be made about seasonal climates?

    A. The temperature range at a rural site throughout a typical day is smaller during the winter than during summer.
    B. The temperature range at a rural site throughout a typical day is larger during the winter than during summer.
    C. The maximum temperature at a rural site throughout a typical winter day is the same as that at an urban site.
    D. The maximum temperature at a rural site throughout a typical winter day is the same as that at a suburban site.

12. According to Study 1, the temperature difference between the urban and the rural sites at 6 P.M. on a typical winter day is approximately:

    F. 1°C.
    G. 4°C.
    H. 7°C.
    J. 10°C.

13. According to Study 3, wind velocity in urban areas increases:

    A. more rapidly with altitude than wind velocity in suburban areas.
    B. at the same rate with altitude as wind velocity in suburban areas.
    C. at the same rate with altitude as wind velocity in rural areas.
    D. more slowly with altitude than wind velocity in rural areas.

Passage III

A chemist performed 3 experiments to determine the boiling points and freezing points of purified water (H_2O) and solutions of various types of solids dissolved in H_2O.

Experiment 1

Fifty milliliters (mL) of H_2O was heated in a beaker. The temperature of the H_2O was recorded every 2 minutes (min) until it remained constant, indicating the boiling point. The procedure was repeated with a solution of 5 grams (g) of sodium chloride (NaCl) in 50 mL of H_2O and with 10 g of NaCl in 50 mL of H_2O. The results are shown in Figure 1.

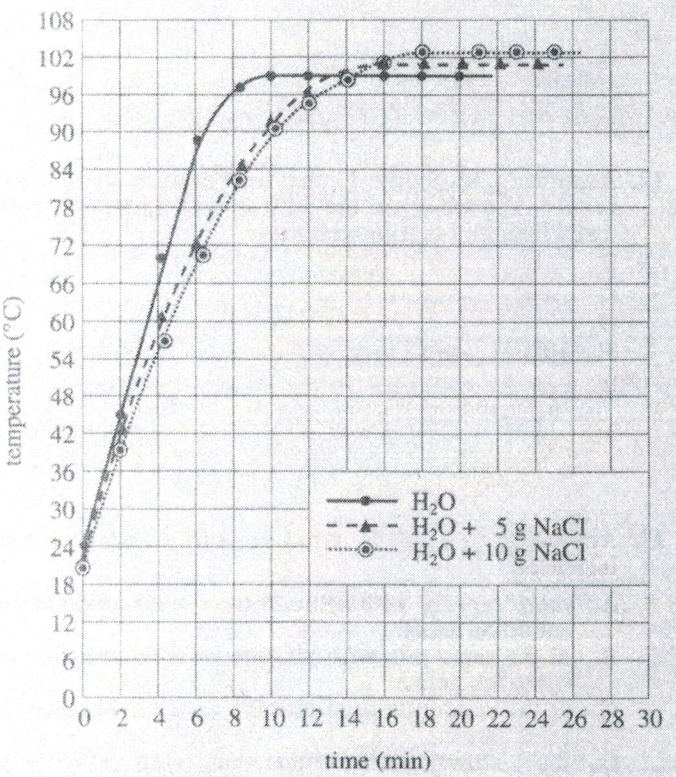


Figure 1

Figure adapted from M. Lesser, C. Constant, and J. Weisler, *Contemporary Science – Book 3*. ©1978 by Amsco School Publications, Inc.

Experiment 2

A beaker containing 50 mL of H_2O was placed in a *dry ice bath* (an insulated bowl of solid CO_2, which produces temperatures below –70°C). When the H_2O began to solidify, the temperature was recorded. The procedure was repeated with various amounts of NaCl added to 50 mL of H_2O. The percentages of NaCl by mass, the masses of NaCl, and the freezing points are shown in Table 1.

Table 1

Solution	% NaCl	Mass of NaCl (g)	Freezing point (°C)
1	0	0.0	0.00
2	3	1.5	–1.85
3	6	3.0	–3.63
4	9	5.0	–5.77
5	13	7.5	–9.03
6	17	10.0	–12.30

Experiment 3

The freezing points of various solutions of potassium chloride (KCl) and calcium chloride ($CaCl_2$) were measured using the same method as in Experiment 2. The results are shown in Tables 2 and 3.

Table 2

Solution	% KCl	Mass of KCl (g)	Freezing point (°C)
7	3	1.5	–1.48
8	6	3.0	–2.80
9	9	5.0	–4.30
10	13	7.5	–6.45
11	17	10.0	N.M.*

* Not measured

Table 3

Solution	% $CaCl_2$	Mass of $CaCl_2$ (g)	Freezing point (°C)
12	3	1.5	–1.47
13	6	3.0	–2.93
14	9	5.0	–5.04
15	13	7.5	–8.72
16	17	10.0	–13.65

14. Which of the following factors was constant throughout all of the experiments?

F. The amount of H_2O
G. The amount of solid dissolved
H. The type of solid dissolved
J. The weight percent of solid dissolved

15. If, in Experiment 3, the chemist had measured the freezing point of Solution 11, the value would most likely be closest to:

A. 0°C.
B. –10°C.
C. –14°C.
D. –17°C.

16. Based on the results of Experiments 2 and 3, the freezing point is influenced by which of the following factors?

F. The type of solid dissolved only
G. The amount of solid dissolved only
H. Both the type and amount of solid dissolved
J. The amount of dry ice used in the dry ice bath

17. Based on the results of Experiment 3, a 7.5% solution of $CaCl_2$ in H_2O would have a freezing point closest to:

A. –2.93°C.
B. –4.01°C.
C. –5.04°C.
D. –8.72°C.

18. Which of the following assumptions did the chemist make about the dry ice used in Experiments 2 and 3 ?

F. Dry ice dissolves in H_2O to form a solution of CO_2 and the added solid.
G. Dry ice does not dissolve in H_2O.
H. The temperature of dry ice is less than the freezing points of the solutions.
J. The temperature of the dry ice is greater than the freezing points of the solutions.

19. Which of the following procedures would most likely raise the freezing point of all of the solutions measured in Experiment 3 ?

A. Adding 1 g of NaCl to the solution
B. Adding 1 g of $CaCl_2$ to the solution
C. Adding 10 mL of H_2O to the solution
D. Adding 1 g of NaCl and 1 mL of H_2O to the solution

Passage IV

A scientist tested the ability of 4 drugs to kill cancer cells.

Experiment 1

Permeability coefficients measure a drug's ability to enter a cell. The larger the permeability coefficient, the faster the drug enters a cell. The molecular mass, in atomic mass units (amu), and permeability coefficient, in centimeters per second (cm/sec), of the 4 drugs at 37°C were measured and are shown in Table 1.

Table 1

Drug	Molecular mass (amu)	Permeability coefficient (cm/sec)
A	485	10^{-5}
B	500	10^{-6}
C	515	10^{-7}
D	530	10^{-8}

Experiment 2

Equal numbers of cancer cells were put into flasks containing 5.0 mL of nutrient medium. The cells were incubated for 1 hour at 37°C with 1 of the 4 drugs shown in Table 2. A control consisted of cells incubated in medium without any drugs. The cells were washed to remove residual drug traces and grown on nutrient plates for 7 days. During this time, the cells reproduced, forming colonies which were then counted. Plates with more colonies were assumed to have more live cells at the end of the 1-hour incubation. Table 2 shows the number of colonies counted. The drug-free control showed 30 colonies.

Table 2

Drug	Drug concentration (μM)*			
	1	5	10	25
A	22	11	4	0
B	26	21	10	1
C	28	23	11	2
D	30	25	12	3

*μM is micromolar
Note: Numbers of colonies are averages for 3 *replicates* (identical samples).

Experiment 3

Cells were handled as described in Experiment 2 with two exceptions: all drugs were tested at the same concentration and incubation time was varied. Table 3 shows the number of colonies counted for Experiment 3.

Table 3

Drug	Incubation time (hours)			
	1	6	12	24
A	12	4	1	0
B	21	8	3	1
C	23	10	5	2
D	25	12	6	3
None	30	30	30	30

Note: Numbers of colonies are averages for 5 replicates.

20. If Experiment 3 were repeated with Drug C and an incubation time of 3 hours, the number of colonies counted would most likely be:

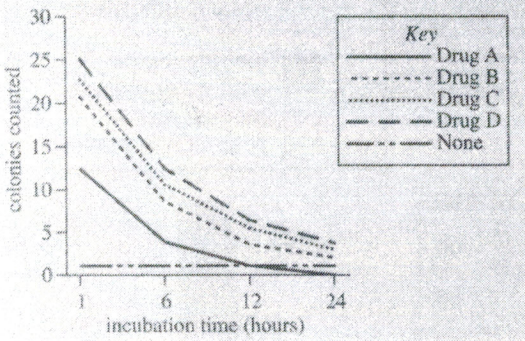
F. less than 11.
G. between 11 and 22.
H. between 23 and 30.
J. greater than 30.

21. Based on the results of Experiment 1, which drug enters cells most quickly?

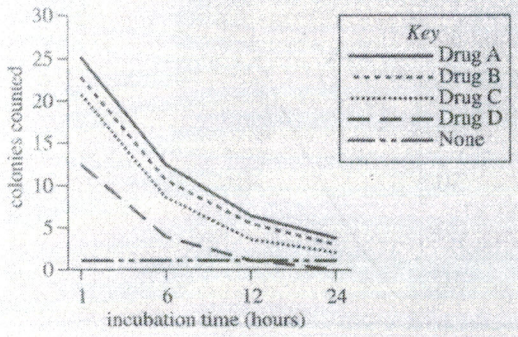
A. Drug A
B. Drug B
C. Drug C
D. Drug D

22. Which of the following graphs best shows the relationship between incubation time and colonies counted in Experiment 3 ?

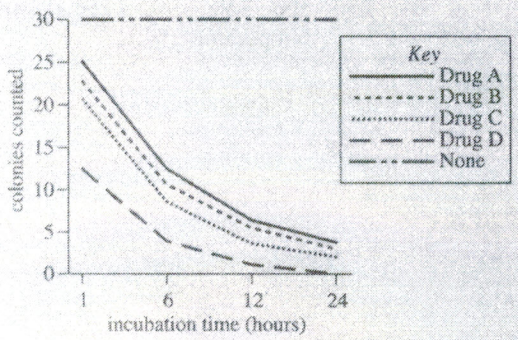
F.



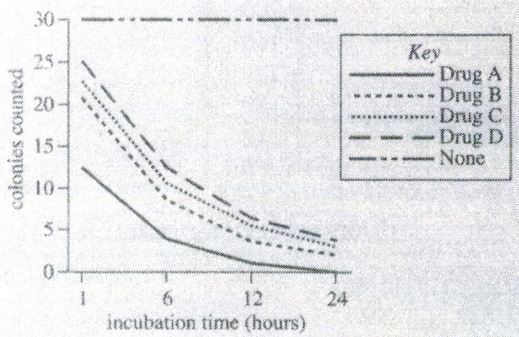
G.



H.



J.



23. Which of the following statements best describes the relationship between the molecular mass and the permeability coefficient of the drugs, as shown in Experiment 1 ?

- **A.** As the molecular mass increases, the permeability coefficient increases.
- **B.** As the molecular mass increases, the permeability coefficient decreases.
- **C.** As the molecular mass decreases, the permeability coefficient decreases.
- **D.** As the molecular mass decreases, the permeability coefficient remains constant.

24. The experimental procedures used in Experiments 2 and 3 differed in that in Experiment 2:

- **F.** incubation time was held constant, while drug concentration was varied.
- **G.** incubation time was varied, while drug concentration was held constant.
- **H.** incubation time and drug concentration were both varied.
- **J.** incubation time and drug concentration were both held constant.

25. In Experiment 2, what was the relationship between drug concentration and the drug's effectiveness in killing cancer cells?

- **A.** All 4 drugs were most effective at the highest concentration used.
- **B.** All 4 drugs were most effective at the lowest concentration used.
- **C.** Some of the drugs were most effective at the lowest concentration used while others were most effective at the highest concentration used.
- **D.** Based on Experiment 2, there is no relationship between drug concentration and effectiveness.

Passage V

Heat flow is the escape of Earth's interior heat through the *lithosphere* (crust and upper mantle combined). For a given thickness, high heat flow indicates a rapid temperature increase with depth. Figure 1 is a cross-sectional view of oceanic and continental lithospheres.

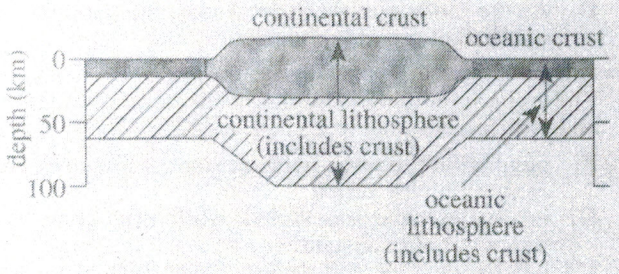
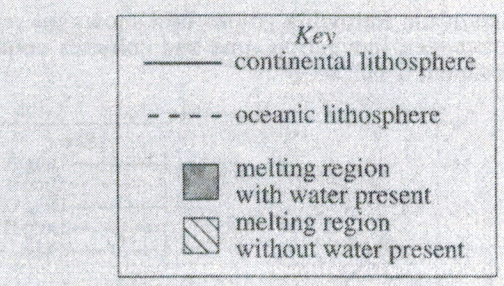


Figure 1

Figure 2 shows heat flow, in watts per square meter (W/m^2), for parts of the oceanic lithosphere and the average heat flows for both lithosphere types.

Figure 3 shows the average relationship between temperature and depth for both lithosphere types. The shaded areas are where lithosphere material would melt with and without water.



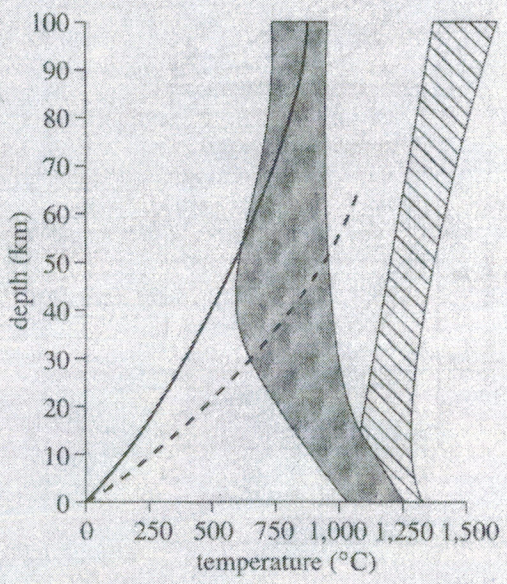


Figure 3

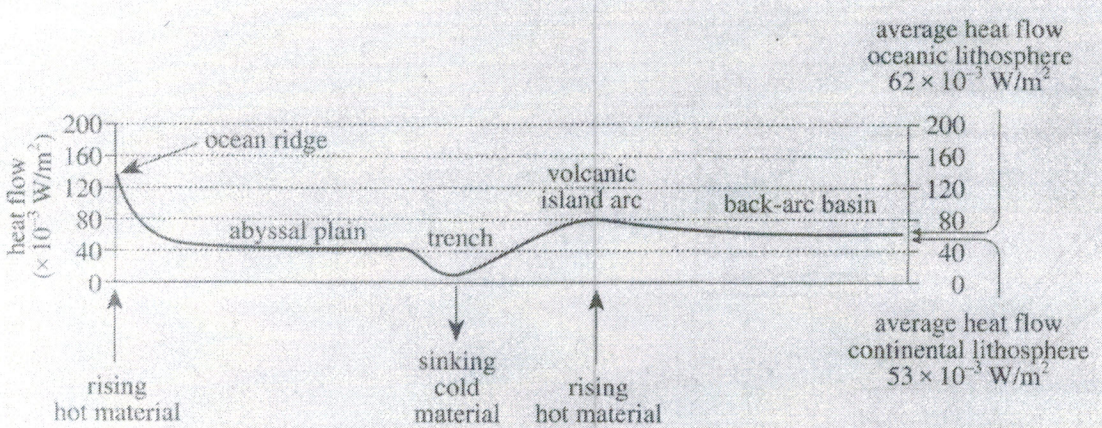
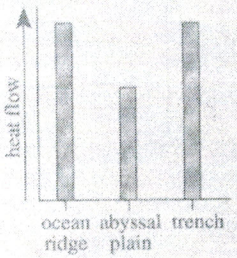


Figure 2

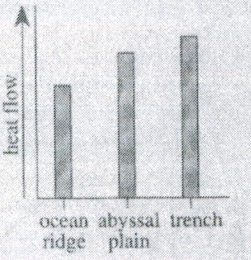
Figures adapted from Frank Press and Raymond Siever, *Earth*. ©1986 by W. H. Freeman and Co.

26. According to Figure 2, which of the following graphs best represents the heat flows from an ocean ridge, an abyssal plain, and a trench?

F.



H.



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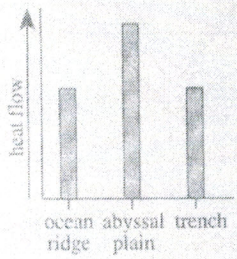

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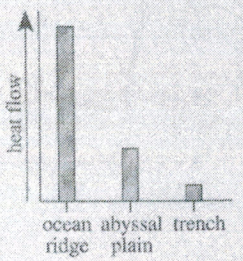


27. According to Figure 2, compared to other heat flow values, the heat flow measured from a back-arc basin is:

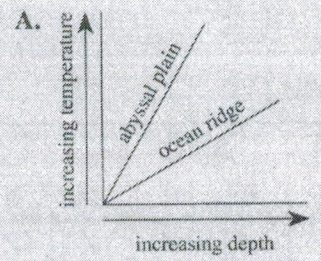
A. much higher than the heat flow from an ocean ridge.
B. approximately the same as the heat flow from a trench.
C. approximately the same as the heat flow from an ocean ridge.
D. approximately the same as the average heat flow for the oceanic lithosphere.

28. Some of the highest heat flows are found over *hydrothermal vents* on the seafloor, where steam and hot water rise out of Earth. According to Figure 2, hydrothermal vents are most likely found in:

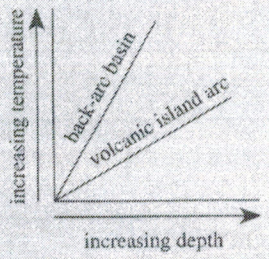
F. ocean ridges.
G. continental mountain ranges.
H. abyssal plains.
J. trenches.

29. If scientists measured how temperature changes with depth in different parts of the oceanic lithosphere, according to Figure 2, which of the following sets of temperature-depth plots would you predict?

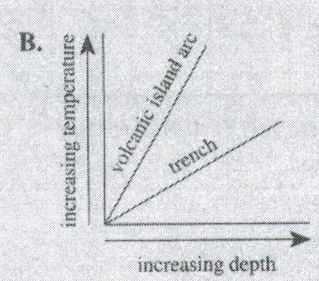
A.



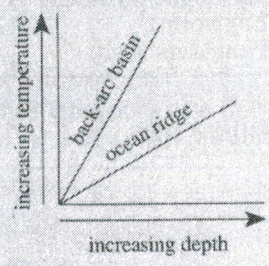
C.



B.



D.



30. According to Figure 3, when comparing the properties of the continental lithosphere to those of the oceanic lithosphere, one would state that the continental lithosphere is:

F. the same temperature as the oceanic lithosphere at any depth.
G. hotter than the oceanic lithosphere at any given depth beneath 10 km.
H. cooler than the oceanic lithosphere at any given depth beneath 10 km.
J. thinner than the oceanic lithosphere.

Passage VI

Scientists established 5 artificial marine ecosystems (A–E) to study the interactions of oil spills and organisms. Table 1 shows what was added to each ecosystem.

Table 1

	Ecosystem				
	A	B	C	D	E
Oil*		✓	✓	✓	✓
Bacteria			✓	✓	
Phosphate fertilizer				✓	✓
Lugworms	✓	✓	✓	✓	✓
Flounders (fish)	✓	✓	✓	✓	✓

*Oil was added at a concentration of 400 parts per million (ppm).

The oil, bacteria, fertilizer, lugworms, and flounders were added in early March. Figure 1 shows how the concentration of oil in Ecosystems B, C, D, and E, and the number of bacteria/mL in Ecosystems C and D changed over 16 months.

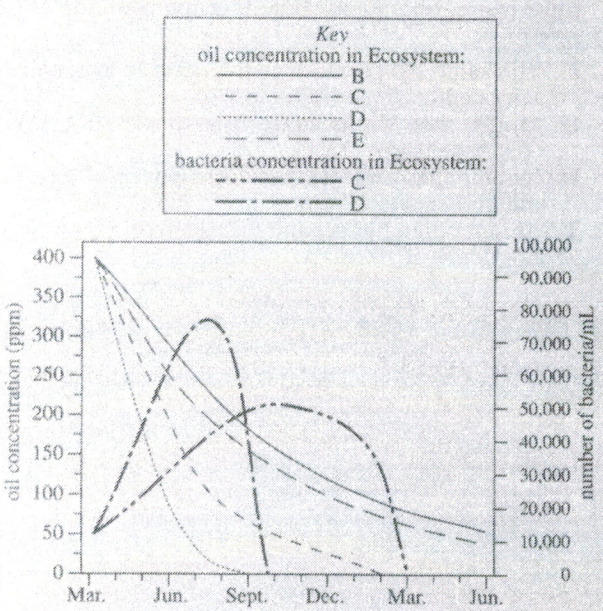


Figure 1

Figure 2 shows how the number of lugworms/m^2 changed over 16 months in each ecosystem.

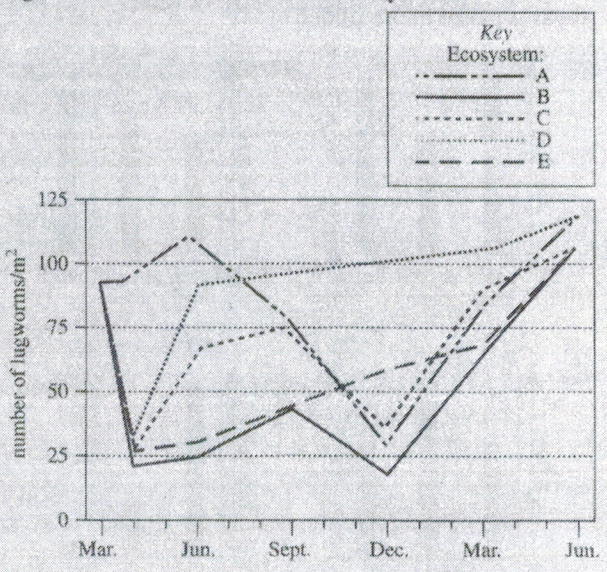


Figure 2

Figure 3 shows how the biomass of flounders in kilograms/1,000 m^3 of water changed over 16 months in each ecosystem.

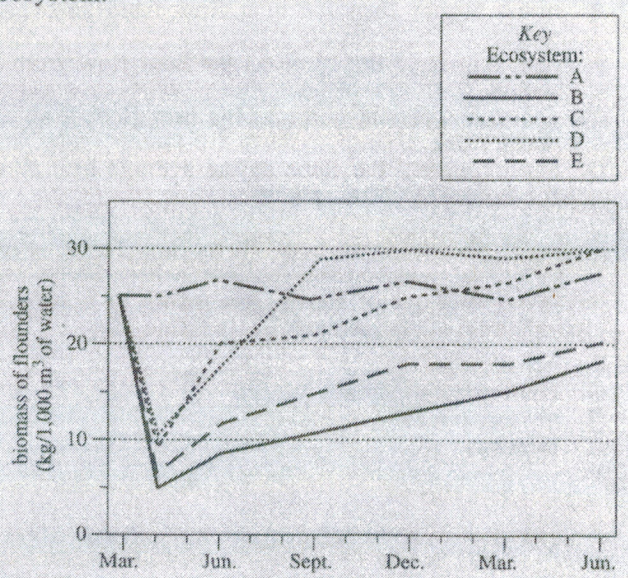


Figure 3

31. According to Figure 1, the oil concentration decreased most rapidly in which ecosystem?

A. Ecosystem B
B. Ecosystem C
C. Ecosystem D
D. Ecosystem E

32. Which of the following reasons best explains why the biomass of the flounders was determined rather than their numbers?

F. Flounders can live longer than 16 months.
G. Flounders do not survive in the presence of oil.
H. A polluted environment may affect the growth of flounders without killing them.
J. It is easier to count flounders than to weigh them.

33. Which of the following conclusions about the effect of oil on flounders in the months following the first month of exposure to oil is supported by Figures 1 and 3 ?

A. As the concentration of oil increased, the biomass of the flounders increased then decreased.
B. As the concentration of oil decreased, the biomass of the flounders decreased.
C. As the concentration of oil decreased, the biomass of the flounders increased.
D. The concentration of oil does not appear to affect flounder biomass.

34. An oil tanker accidentally spilled oil into a marine ecosystem. According to Figures 1–3, one would advise the cleanup crew to add which of the following to the oil spill to best speed cleanup?

F. Lugworms only
G. The phosphate fertilizer only
H. Lugworms and flounders only
J. The bacteria and phosphate fertilizer only

35. Which of the following pieces of evidence best supports the conclusion that the bacteria added to the ecosystems could only feed on oil?

A. The oil concentration decreased more slowly when bacteria were present.
B. The bacterial populations decreased to zero soon after the oil concentration was zero.
C. The size of the bacterial populations was greatest when the concentration of oil was greatest.
D. Flounder biomass increased even in the presence of bacteria.

Passage VII

According to a simplified model of the hydrogen atom, an *electron* orbits a *proton* located at the center of the atom. The electron can exist only in certain orbits, each with a specific radius. When the electron jumps from one orbit to another orbit of smaller radius, the atom emits a packet of energy known as a *photon*.

The electron jumps shown in Figure 1, which involve the first 6 orbits, result in the emission of 3 types of photons—ultraviolet, visible, and infrared. The energies and *wavelengths* of the photons emitted due to these jumps are shown in Table 1.

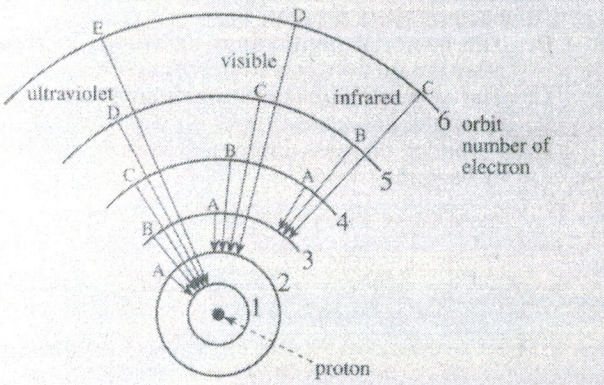


Figure 1

(Note: Diagram is not drawn to scale.)

Figure adapted from Edwin R. Jones and Richard L. Childers, *Contemporary College Physics*. ©1993 by Addison-Wesley Publishing Company, Inc.

Table 1

Type of photon	Jump	Energy of photon (eV)*	Wavelength of photon (nm)†
Ultraviolet	A	10.2	122
	B	12.1	103
	C	12.8	97.3
	D	13.1	94.9
	E	13.2	93.8
Visible	A	1.89	656
	B	2.55	486
	C	2.86	434
	D	3.02	410
Infrared	A	0.661	1,880
	B	0.967	1,280
	C	1.13	1,090

* eV = electron volt
† nm = nanometer

36. According to Figure 1, a hydrogen atom can emit any one of the 3 types of photons when the electron jumps from all of the following orbits EXCEPT:

F. Orbit 3.
G. Orbit 4.
H. Orbit 5.
J. Orbit 6.

37. When a hydrogen atom absorbs energy, the electron can jump from one orbit to another orbit of larger radius. Suppose the electron has jumped from Orbit 1 to Orbit 5 due to the absorption of the energy of a single photon. Based on Figure 1, it is most likely that the atom absorbed:

A. an ultraviolet photon.
B. a visible photon.
C. an infrared photon.
D. a photon that is neither ultraviolet, nor visible, nor infrared.

38. According to Table 1, the statement "As photon wavelength decreases, photon energy increases" is true for which types of photons?

F. Ultraviolet and visible only
G. Ultraviolet and infrared only
H. Visible and infrared only
J. Ultraviolet, visible, and infrared

39. According to Figure 1, if the electron in a hydrogen atom jumps from Orbit 6 to Orbit 3, and then jumps from Orbit 3 to Orbit 1, the atom will emit:

A. one infrared photon only.
B. one ultraviolet photon only.
C. one infrared photon, followed by one ultraviolet photon.
D. one ultraviolet photon, followed by one infrared photon.

GO ON TO THE NEXT PAGE.

40. Based on the information presented, which of the following statements about the relationship between the electron's orbit number and the energy of the hydrogen atom is most likely true?

F. As the electron's orbit number increases, the energy of the hydrogen atom increases.
G. As the electron's orbit number increases, the energy of the hydrogen atom decreases.
H. As the electron's orbit number increases, the energy of the hydrogen atom increases and then decreases.
J. As the electron's orbit number increases, the energy of the hydrogen atom remains the same.

END OF TEST 4

STOP! DO NOT RETURN TO ANY OTHER TEST.