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SCIENCE TEST

30 Minutes—30 Questions

DIRECTIONS: There are several 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 folder. You may refer to the passages as often as necessary.

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

Passage I

Two species of aquatic plants, Species A and Species B, are often found in the same freshwater lakes. Both species can grow in water up to 2 m deep. However, typically, Species A is found closer to the lake's edge in shallower water whereas Species B grows farther out in deeper water. Both species spread by means of underground stems called *rhizomes* and by means of seeds. A scientist conducted 2 studies to examine the effect of water depth on the growth of Species A and Species B plants from seeds.

Study 1

In early June, seeds from Species A and Species B were germinated. In mid-June, 24 seedlings of each species, all having shoot lengths of 3 cm to 5 cm, were transferred to identical pots (1 seedling per pot). The pots were suspended beneath the water in large outdoor tanks that were located in full sun. Eight seedlings of each species were submerged to each of 3 water depths—0.2 m, 0.4 m, and 0.8 m. In late September, the average shoot length for surviving Species A seedlings and Species B seedlings at each of the 3 water depths was determined. The results are shown in Figure 1.

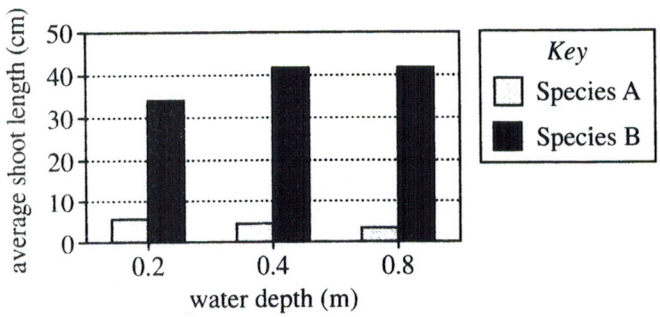

Figure 1

Study 2

Immediately after Study 1, the surviving seedlings of Species A and B were removed from the tanks, dried, and then weighed. The average dry mass of the surviving Species A seedlings from each water depth was 2.3 mg. The average dry mass of the surviving Species B seedlings from each water depth is shown in Figure 2.

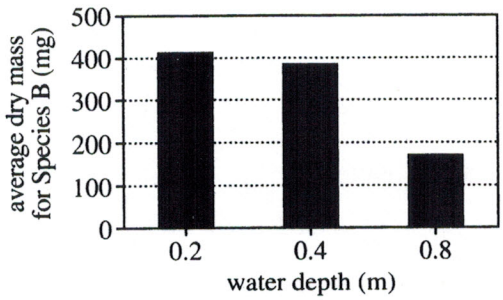

Figure 2

For each water depth, the shoot length and dry mass of each surviving Species B seedling were plotted. The best-fit curve for each set of data points is shown in Figure 3.

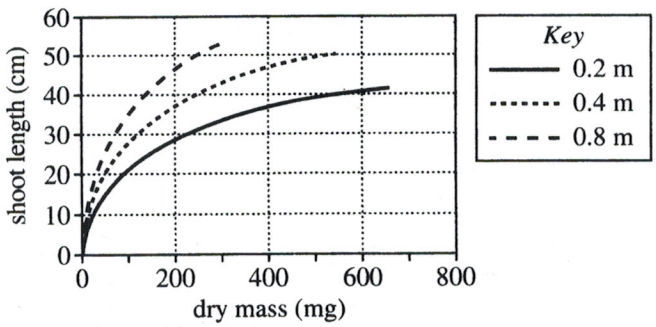

Figure 3

Figures adapted from Stefan E. B. Weisner et al., "Influence of Submergence on Growth of Seedlings of *Scirpus lacustris* and *Phragmites australis*." ©1993 by Blackwell Publishing.

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1. Based on Figure 3, for a water depth of 0.8 m, the shoot length and dry mass of how many Species B seedlings were plotted?

   A. 5
   B. 8
   C. 24
   D. Cannot be determined from the given information

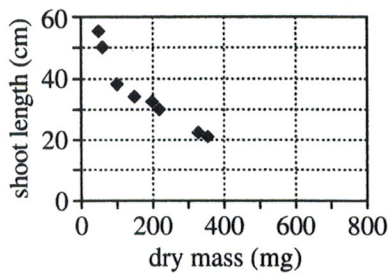
2. Suppose that a fourth group of pots containing Species B seedlings had been suspended at a water depth of 0.3 m. The average shoot length of these seedlings in late September would most likely have been:

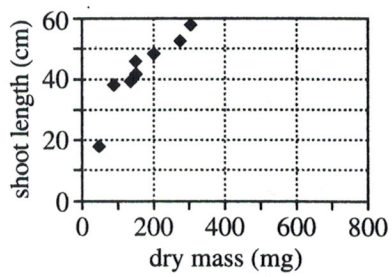
   F. less than 34 cm.
   G. between 34 cm and 42 cm.
   H. between 42 cm and 50 cm.
   J. greater than 50 cm.

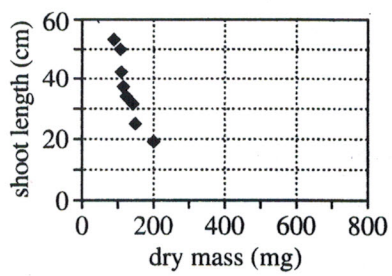
3. At the conclusion of Study 2, a seedling of Species B was found to have a dry mass of 400 mg and a shoot length of 33 cm. Based on Figure 3, this seedling most likely had been submerged at which of the following water depths?

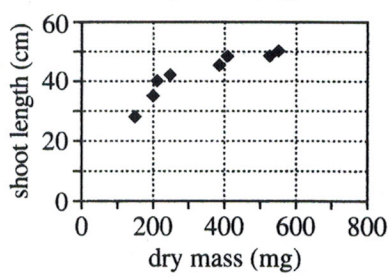
   A. 0.2 m
   B. 0.4 m
   C. 0.8 m
   D. 1.0 m

4. Which of the following sets of data points most likely yielded the best-fit curve for surviving Species B seedlings grown at a depth of 0.4 m ?

   F.
   

   G.
   

   H.
   

   J.
   

5. According to the results of Studies 1 and 2, for a given water depth, how did surviving seedlings of Species A compare to surviving seedlings of Species B ? On average, seedlings of Species A had:

   A. longer shoot lengths and greater dry mass.
   B. longer shoot lengths but lesser dry mass.
   C. shorter shoot lengths and lesser dry mass.
   D. shorter shoot lengths but greater dry mass.

6. Of the 8 Species A seedlings grown at a water depth of 0.2 m, 6 survived. The *total* dry mass of these surviving seedlings can be calculated using which of the following expressions?

   F. 2.3 mg × 6
   G. 2.3 mg ÷ 6
   H. 2.3 mg × 8
   J. 2.3 mg ÷ 8

GO ON TO THE NEXT PAGE.

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Passage II

In mountainous regions, a *terrace* is made by first building a low rock wall, then creating an area of level soil behind the wall (see Figure 1). Rainfall erodes the soil from terraces at different rates depending on whether a terrace is being farmed or is being used for animal grazing.

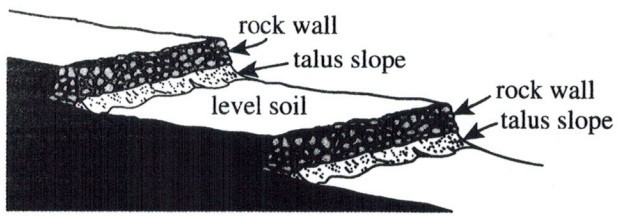


Figure 1

A study done in June of one year considered 86 terraces in the same 100 km^2 mountainous region, all at approximately the same altitude. Each terrace was assigned to 1 of 3 categories: farmed, lightly grazed, or heavily grazed. Also studied were *talus slopes*, which are inclined areas composed of rock fragments and small amounts of soil.

For each terrace or talus slope, erosion was measured in 5 different locations. At each location, a 1,385 cm^2 area was isolated, and simulated rainfall was applied evenly to the area at a rate of 75 mm/hr for 45 min. The *time to runoff* (time elapsed between the beginning of rainfall and the beginning of runoff) was recorded (in sec).

All runoff from each isolated area was collected over the 45 min to determine the runoff rate (in mm/hr), the soil concentration in the runoff (in g/L), and the soil erosion rate (in $g/m^2/hr$). The *wetting front* was also determined at the end of 45 min. The wetting front was the depth (in cm) to which rainwater had infiltrated the soil. The results, averaged for each of the 4 types of surfaces, are shown in Table 1.

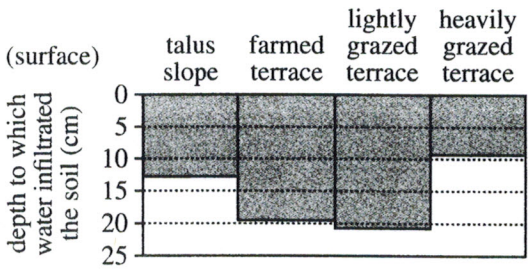
Table 1

Type of surface		Time to runoff (sec)	Runoff rate (mm/hr)	Soil concentration (g/L)	Soil erosion rate ($g/m^2/hr$)	Wetting front (cm)
Talus slope		301	36.7	0.77	22.0	12.7
Terrace	farmed	629	18.5	0.41	10.2	19.1
	lightly grazed	645	16.2	0.33	7.1	21.1
	heavily grazed	398	35.1	0.82	26.1	9.8

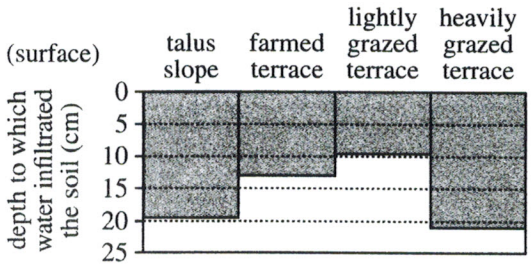
Figure and table adapted from Teodoro Lasanta et al., "Marginal Lands and Erosion in Terraced Fields in the Mediterranean Mountains." ©2001 by the International Mountain Society and the United Nations University.

7. Which of the following graphs best represents the wetting front results in Table 1 ?

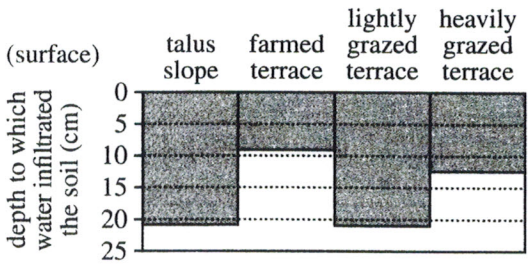
A.



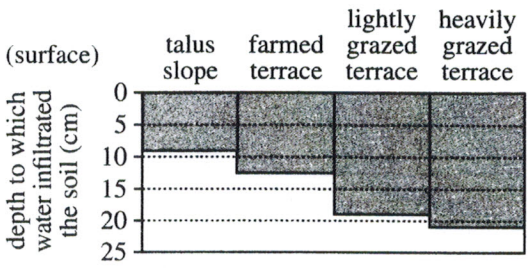
B.



C.



D.



8. Is the statement "The average soil erosion rate was greatest for the talus slopes" supported by the results of the study?

F. Yes; the average soil erosion rate for the talus slopes was greater than that for any of the 3 categories of terraces.
G. Yes; the average soil erosion rate for the talus slopes was less than that for any of the 3 categories of terraces.
H. No; the average soil erosion rate for the talus slopes was greater than that for the farmed terraces and that for the lightly grazed terraces, but less than that for the heavily grazed terraces.
J. No; the average soil erosion rate for the talus slopes was greater than that for the farmed terraces, but less than that for the lightly grazed terraces and that for the heavily grazed terraces.

9. The most likely reason that terraces located in the same mountainous region were selected for study was to ensure that the terraces would be as similar as possible with respect to which of the following variables?

A. Soil erosion rate
B. Runoff rate
C. Climate
D. Terrace category

10. According to the results of the study, for the farmed terraces, the average time elapsed between the beginning of the simulated rainfall and the beginning of runoff, in *min*, was closest to which of the following?

F. 5 min
G. 10 min
H. 15 min
J. 20 min

11. Do the results of the study support the statement "On average, for all 4 types of surfaces, all of the simulated rainfall that was applied ran off"?

A. Yes, because for all 4 types of surfaces the runoff rate was greater than 75 mm/hr and the wetting front was zero.
B. Yes, because for all 4 types of surfaces the runoff rate was less than 75 mm/hr and the wetting front was greater than zero.
C. No, because for all 4 types of surfaces the runoff rate was greater than 75 mm/hr and the wetting front was zero.
D. No, because for all 4 types of surfaces the runoff rate was less than 75 mm/hr and the wetting front was greater than zero.

12. Which of the following statements best explains why the soil erosion rate for heavily grazed terraces differed from the soil erosion rate for lightly grazed terraces? Heavily grazed terraces had:

F. more vegetation cover than did lightly grazed terraces, and therefore were more resistant to erosion.
G. more vegetation cover than did lightly grazed terraces, and therefore were less resistant to erosion.
H. less vegetation cover than did lightly grazed terraces, and therefore were less resistant to erosion.
J. less vegetation cover than did lightly grazed terraces, and therefore were more resistant to erosion.

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Passage III

When a sphere falls through air, the sphere is subjected to a drag force, F, that resists its motion. F depends on the sphere's diameter, D; the air temperature, T; the sphere's speed, V; and atmospheric pressure.

The table below gives F, in newtons (N), on a sphere falling through air near Earth's surface, for various combinations of D, in meters (m); T, in degrees Celsius (°C); and V, in meters per second (m/sec). For each combination, air pressure is 1 atmosphere.

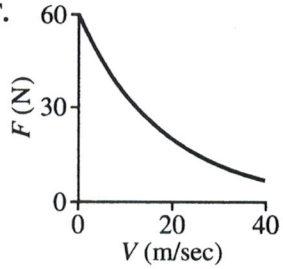
Combination	D (m)	T (°C)	V (m/sec)	F (N)
1	0.050	25.0	20.0	0.93
2	0.100	25.0	20.0	3.71
3	0.150	25.0	20.0	8.34
4	0.200	25.0	20.0	14.9
5	0.200	10.0	20.0	15.8
6	0.200	15.0	20.0	15.5
7	0.200	20.0	20.0	15.1
8	0.200	25.0	20.0	14.9
9	0.200	25.0	10.0	3.72
10	0.200	25.0	20.0	14.9
11	0.200	25.0	30.0	33.5
12	0.200	25.0	40.0	59.5

13. According to Combinations 5–8, as T increases, F:

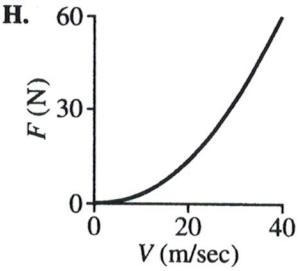
A. increases only.
B. decreases only.
C. varies, but with no general trend.
D. remains the same.

14. Based on Combinations 9–12, the relationship between F and V is best represented by which of the following graphs?

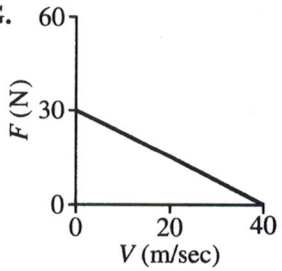
F.



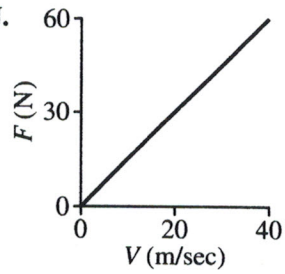
H.



G.



J.



15. Based on the table, F will be greatest for which of the following D, T, and V?

	D (m)	T (°C)	V (m/sec)
A.	0.400	30	100
B.	0.400	60	200
C.	0.800	60	100
D.	0.800	30	200

16. If experimental trials were conducted in which Combinations 1–4 were tested, what would be the independent variable and what would be the dependent variable?

	independent	dependent
F.	V	T
G.	T	V
H.	F	D
J.	D	F

17. As a sphere moves as described in the passage, a transformation of energy takes place involving the sphere's kinetic energy (KE_S), the sphere's potential energy due to Earth's gravity (GPE_S), and heat (Q). Which of the following statements best describes this transformation?

A. Both GPE_S and Q are converted to KE_S.
B. Both KE_S and Q are converted to GPE_S.
C. GPE_S is converted to KE_S and Q.
D. Q is converted to GPE_S and KE_S.

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Passage IV

Both bats and birds have wings used for flight. Two students present opposing views about whether the presence of the wings is an indication that bats and birds are more closely related to each other than either is to other vertebrates without wings, such as humans. Included in each student's presentation is a *cladogram*, a diagram that shows the evolutionary history of several species. A cladogram organizes species into clades based on descent from a common ancestor. A *clade* is a set of related species and their *most recent common ancestor* (MRCA).

Student 1

Although both have wings, bats and birds are not more closely related to each other than either is to other vertebrates without wings. Although the wings of bats and birds evolved in response to similar selective forces, they evolved independently of one another, as shown in Figure 1. The wings of birds evolved at Point A, whereas the wings of bats evolved at Point B.

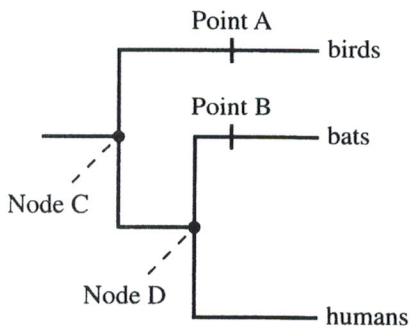


Figure 1

A bat can move individual wing bones, much like the fingers can be moved in a human hand. The bones in a bird wing are fused and inflexible. Thus, the bone structure of a bat wing is more similar to the bone structure of a human hand than to the bone structure of a bird wing. Furthermore, the fact that both bats and humans share mammalian characteristics provides additional evidence that bats are more closely related to humans than to birds.

Student 2

Their both having wings is a good indication that bats and birds are more closely related to each other than either is to other vertebrates without wings. The MRCA of all vertebrates with wings must have had wings. As shown in Figure 2, the MRCA of bats and birds, represented at Node Z, evolved to give rise to all winged vertebrates.

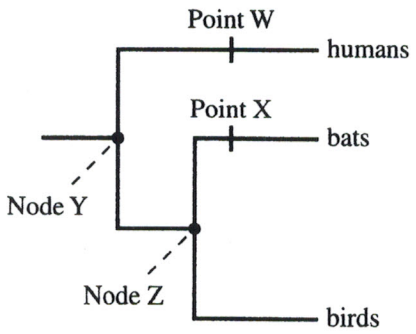


Figure 2

Evidence that the bone structure of a bat wing is similar to that of a human hand does not indicate that bats and humans are closely related because bats, birds, and humans all have a similar forelimb bone structure. Humans and bats are both mammals, but the mammalian characteristics of humans and of bats evolved at Points W and X, respectively.

18. Student 2's cladogram indicates that which of the vertebrates listed below belong to the clade that originates at Node Z ?

I. Humans
II. Bats
III. Birds

F. I only
G. I and II only
H. II and III only
J. I, II, and III

19. Consider the statement "Bats have a small claw that sticks out of the wing and functions like a human thumb, allowing the bat to hang onto and climb on trees." This statement supports the view of which student?

A. Student 1, because Student 1 claims that any descendant of an ancestor with forelimbs will have a nonfunctional structure that resembles a human thumb.
B. Student 1, because Student 1 claims that the similarity of bone structure between a bat wing and a human hand provides evidence that bats and humans are closely related.
C. Student 2, because Student 2 claims that any descendant of an ancestor with forelimbs will have a nonfunctional structure that resembles a human thumb.
D. Student 2, because Student 2 claims that the similarity of bone structure between a bat wing and a human hand provides evidence that bats and humans are closely related.

20. In Student 1's cladogram, is the MRCA of bats and humans represented at Node C or at Node D ?

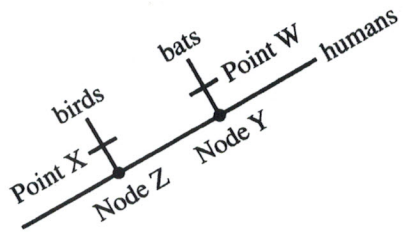
F. Node C, because the clade that begins with the ancestor represented at Node C includes bats and humans, as well as birds, as descendants.
G. Node C, because the clade that begins with the ancestor represented at Node C includes bats and humans, but not birds, as descendants.
H. Node D, because the clade that begins with the ancestor represented at Node D includes bats and humans, as well as birds, as descendants.
J. Node D, because the clade that begins with the ancestor represented at Node D includes bats and humans, but not birds, as descendants.

21. Which of the students, if either, present(s) a cladogram that is consistent with the statement "Birds and humans, but not bats, share a common ancestor that had forelimbs"?

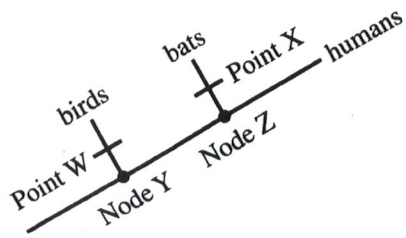
A. Student 1 only
B. Student 2 only
C. Both Student 1 and Student 2
D. Neither Student 1 nor Student 2

22. Which of the following cladograms is consistent with the cladogram constructed by Student 2 ?

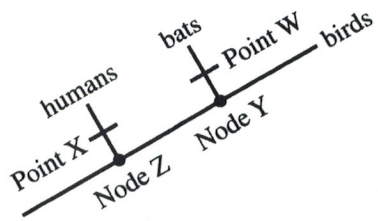
F.



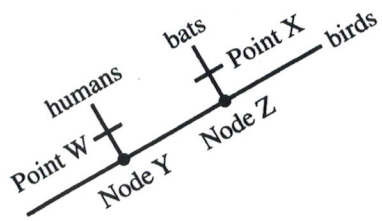
G.



H.



J.



23. Which of the students, if either, would be likely to claim that the MRCA of bats and birds did *not* have wings?

A. Student 1 only
B. Student 2 only
C. Both Student 1 and Student 2
D. Neither Student 1 nor Student 2

24. Student 2 implies that which of the following morphological traits evolved at Points W and X ?

F. Wings for flight
G. Forelimbs
H. Hands
J. Mammary glands

Passage V

When an oil is exposed to air, small amounts of reactive *peroxides* can form in the oil. If the peroxide concentration reaches a certain level, the oil will rapidly decompose to form acidic organic compounds such as formic acid. Scientists use an *accelerated oxidation apparatus*, AOA, to model this process on a short time scale (see diagram).

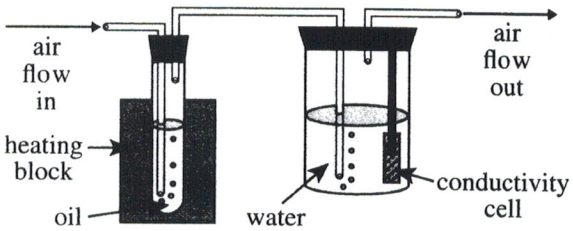


diagram of AOA

A 3 g oil sample is heated to a certain temperature. Starting at time = 0 min, dry air is bubbled through the sample at a constant rate. The flow of air carries organic acids produced in the sample into the flask containing water. The *conductivity* (ease of electric flow) of the water is monitored. The conductivity of the water stays relatively constant until the oil rapidly decomposes. As the oil rapidly decomposes, the conductivity sharply increases. The length of time from 0 min until this increase occurs is the *induction period*.

Biodiesels are renewable fuel oils typically made from soybeans. Scientists did 3 experiments to study 4 biodiesels (BD1–BD4). BD2 was a 50/50 mixture of BD1 and BD4 by volume.

Experiment 1

The induction period was determined for fresh samples of BD1–BD4 at 4 temperatures (see Figure 1).

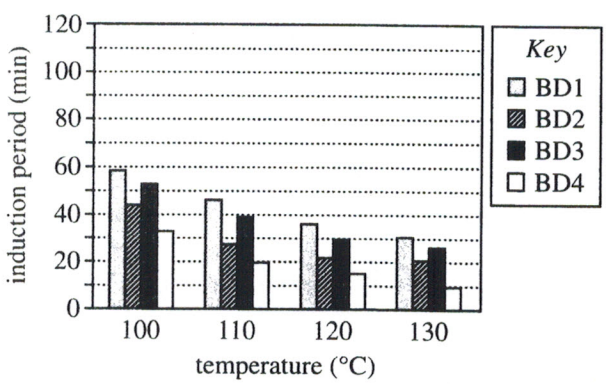


Figure 1

Experiment 2

The induction period was determined for fresh samples of BD1–BD4 at 110°C. Each sample contained 1 of 4 *antioxidants* at a concentration of 500 mg/kg (see Figure 2). Antioxidants are compounds that can inhibit the decomposition of oils exposed to air.

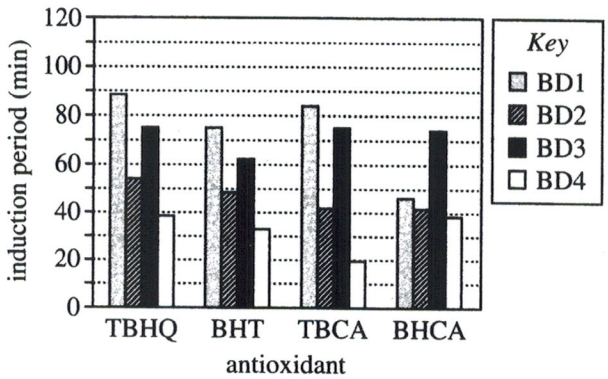


Figure 2

Experiment 3

The induction period was determined for fresh samples of BD1–BD4 at 110°C. Each sample contained a different concentration of the antioxidant TBHQ (see Figure 3).

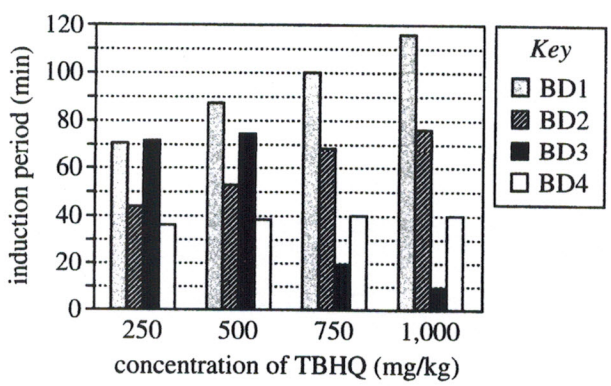


Figure 3

Figures adapted from S. R. Westbrook, *An Evaluation and Comparison of Test Methods to Measure the Oxidation Stability of Neat Biodiesel.* National Renewable Energy Laboratory, 2005.

25. In Experiment 3, which of the biodiesels having a TBHQ concentration of 750 mg/kg decomposed most quickly in the AOA ?

A. BD1
B. BD2
C. BD3
D. BD4

26. A chemist claims that if the antioxidant concentration in a biodiesel is increased from 500 mg/kg to 1,000 mg/kg, the biodiesel's stability will increase. The claim is *inconsistent* with the results in Experiment 3 for which biodiesel?

F. BD1
G. BD2
H. BD3
J. BD4

27. Suppose a set of trials had been done in Experiment 1 at 115°C. Which of the following would have been the most likely induction periods of BD2 and BD3 ?

	BD2	BD3
A.	25 min	35 min
B.	30 min	35 min
C.	35 min	25 min
D.	35 min	30 min

28. A sample of fresh BD1 is tested in the AOA as in Experiment 1 and is found to have an induction period of 65 min. At which of the following temperatures was the test most likely conducted?

F. 95°C
G. 105°C
H. 115°C
J. 125°C

29. In Experiments 1–3, the component of the air bubbling through the biodiesel sample that was primarily responsible for the breakdown of the sample was:

A. H_2O.
B. H_2.
C. N_2.
D. O_2.

30. Suppose BD5 is made by mixing 250 mL of BD1 with 750 mL of BD4. If a sample of BD5 containing 500 mg/kg of TBCA were tested as in Experiment 2, its induction period would most likely be:

F. less than 20 min.
G. between 20 min and 40 min.
H. between 40 min and 80 min.
J. greater than 80 min.

END OF TEST 4

STOP! DO NOT RETURN TO ANY OTHER TEST.

ACT

Student Report

Your Item Response Analysis

Ask for your test booklet so you can review the questions and your answers. Ideas for Progress are based on your scores. The improvement suggestions provided are a sample of the Ideas for Progress for your subject scale score. Your particular profile of strengths and weaknesses will influence which suggestions are most relevant for you. More information can be found at www.act.org/standards/ideasforprogress.

MATH

Correctly Answered: 13 of 36
Omitted: 10 of 36
Incorrectly Answered: 13 of 36

Question	Correct Answer	Incorrect Response
1	E	
2	J	
3	C	
4	J	
5	B	
6	G	
7	D	
8	K	
9	E	
10	G	
11	E	
12	K	
13	D	-
14	F	
15	C	-
16	H	-
17	C	
18	G	
19	D	
20	H	

Question	Correct Answer	Incorrect Response
21	C	
22	G	-
23	A	
24	G	
25	E	-
26	K	
27	A	
28	H	-
29	B	
30	K	
31	D	-
32	J	-
33	D	
34	F	-
35	B	-
36	F	

Ideas for Progress

Number and Quantity

- recognize, identify, and apply basic properties of real numbers (e.g. commutative, associative, identities)

Algebra

- evaluate algebraic expressions and solve simple equations, using integers for Algebra

Functions

- use function notation to create equations that model real-world and mathematical problems

Geometry

- find area and perimeter of triangles and rectangles by substituting given values into standard geometric formulas

Statistics and Probability

- gather, organize, display, and analyze data in a variety of ways for use in problem solving

SCIENCE

Correctly Answered: 15 of 30
Omitted: 0 of 30
Incorrectly Answered: 15 of 30

Question	Correct Answer	Incorrect Response
1	D	
2	G	
3	A	
4	J	
5	C	
6	F	
7	A	
8	H	
9	C	
10	G	
11	D	
12	H	
13	B	
14	H	
15	D	
16	J	
17	C	
18	H	
19	B	
20	J	

Question	Correct Answer	Incorrect Response
21	D	
22	J	
23	A	
24	J	
25	C	
26	H	
27	A	
28	F	
29	D	
30	G	

Ideas for Progress

Interpretation of Data

- create a visual display that summarizes a set of raw data

Scientific Investigations

- Summarize the design of experiments, including the questions asked, the variables manipulated, and the methods used

Evaluation of Models

- Compare models that explain different phenomena, including how they support their claims

A blank response is marked with a dash (-).
A response with more than one answer is marked with an asterisk (*).