Chris

Lesson 3

SCIENCE TEST

35 Minutes—40 Questions

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

Lyme disease is caused by bacteria that are transmitted to humans by the bite of infected deer ticks. The first sign of Lyme disease is often a bull's-eye rash on the skin. Figure 1 shows the 2-year deer tick life cycle.

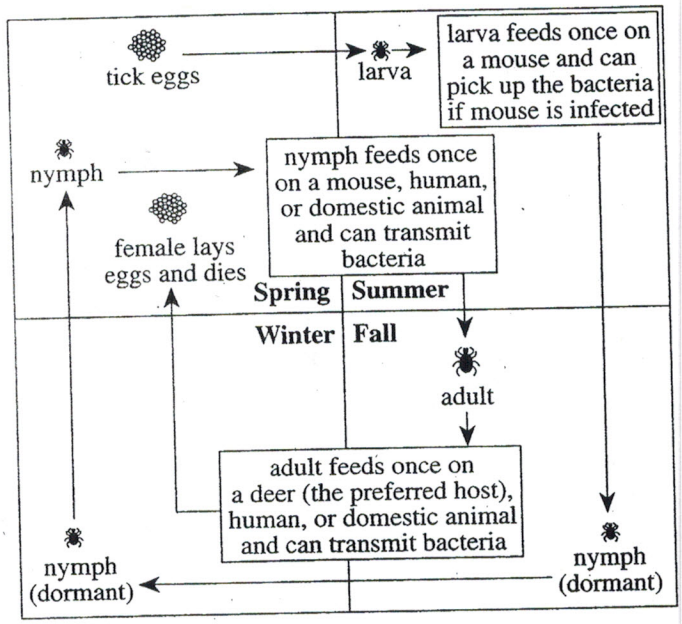
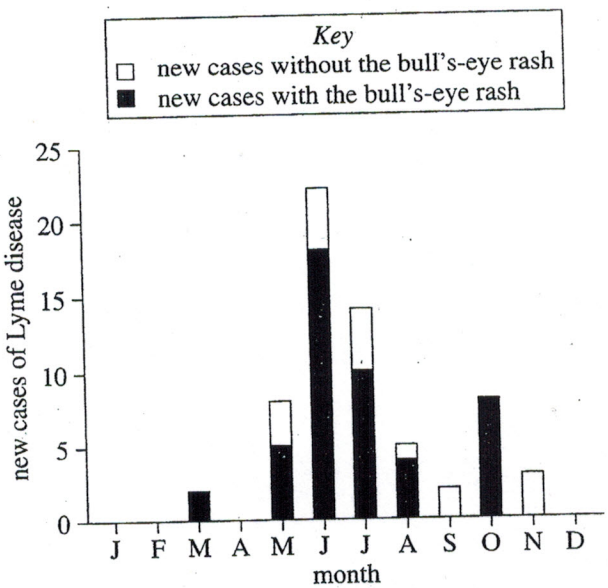


Figure 1

Figure 1 adapted from "Deer Tick Ecology." ©1998 by the American Lyme Disease Foundation, Inc.

A study area adjacent to a forest was divided into 5 zones (A–E). People living in the study area were tested monthly for Lyme disease. The results are shown in Figure 2. For each zone, Table 1 shows the number of houses, mice, deer tick larvae per mouse, households that sighted deer daily, and the percent of households inhabited by at least 1 person infected with Lyme disease.



Note: Bars on the graph are stacked.

Figure 2

Table 1

Zone	Number of: houses	mice	larvae/mouse	households that sighted deer daily	Percent of households inhabited by at least 1 infected person
A	12	300	50	12	75
B	13	203	19	10	62
C	13	128	23	8	54
D	13	108	67	4	38
E	14	93	20	6	36

Figure 2 and Table 1 adapted from Catherine C. Latavica et al., "Rapid Emergence of a Focal Epidemic of Lyme Disease in Coastal Massachusetts." ©1989 by The Massachusetts Medical Society.

1. Based on Table 1, as the number of mice found in a given zone increased, the number of larvae per mouse:

   A. increased only.
   B. decreased only.
   C. decreased, then remained the same.
   D. varied with no general trend.

2. Based on Figure 1, which organism is essential in maintaining the Lyme disease bacteria in the deer tick population?

   F. Deer
   G. Mice
   H. Humans
   J. Domestic animals

3. Based on Table 1, the average percent of households inhabited by at least 1 infected person in Zones A–E of the study area was closest to:

   A. 30%.
   B. 40%.
   C. 50%.
   D. 60%.

4. Suppose additional data had been obtained about the total number of infected deer tick larvae in each of the zones. Given Table 1, one would predict that the largest total of infected deer tick larvae would have been found in which zone?

   F. Zone A
   G. Zone B
   H. Zone D
   J. Zone E

5. According to Figure 2, the total number of new cases of Lyme disease was the same for both months in each of the following pairs of months EXCEPT:

   A. March and September.
   B. April and December.
   C. May and October.
   D. August and November.

Passage II

Oxyfluorocarbons (OFCs) are oils composed of only carbon (C), fluorine (F), and oxygen (O). They are useful as lubricants in exposed mechanical systems on spacecraft. However, OFCs tend to decompose upon exposure to heated metal surfaces, which usually have a *metal oxide* (MO) outer layer (see Figure 1).

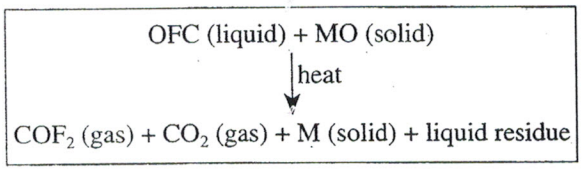


Figure 1

When an oil decomposes, the mechanical systems stop working, crippling the spacecraft.

Chemists studied the decomposition of 2 OFCs (OFC1 and OFC2).

Experiment 1

In a chamber at 100°C and 0.01 atmospheres (atm) pressure, 1.5 g of OFC1 was mixed with 50 mg of powdered iron(III)oxide (Fe_2O_3), an MO. The gases produced by the decomposition of the OFC caused the pressure to increase. The *induction period* (the time for the pressure to rise to 0.20 atm) was measured. Shorter induction periods indicate more rapid decomposition. The procedure was repeated at different temperatures, and for OFC2 (see Table 1).

Table 1

Temperature (°C)	Induction period (sec)	
	OFC1	OFC2
100	1,800	998
120	903	603
140	442	301
160	218	133
180	111	52
200	55	18
220	29	6

Experiment 2

The induction periods of OFC1 with various powdered Fe compounds were measured as in Experiment 1 at 180°C (see Table 2). Some of these compounds are hypothesized to exist on heated metal surfaces, or to form as minor by-products of the reaction shown in Figure 1.

Table 2

Compound	Formula	Induction period (sec)
Iron(II)*oxide	FeO	5,784
Iron(III)fluoride	FeF_3	3
Iron(III)chloride	$FeCl_3$	48
Iron(III)carbonate	$Fe_2(CO_3)_3$	996
Iron(III)sulfate	$Fe_2(SO_4)_3$	998

*Roman numerals in parentheses indicate the amount of positive charge on the iron atom.

6. If, in Experiment 1, a trial had been done at 150°C, the induction periods (in sec) for OFC1 and OFC2 would most likely have been which of the following?

	OFC1	OFC2
F.	203	311
G.	311	203
H.	301	442
J.	442	301

7. Based on the results of Experiment 2, which compound produced the fastest decomposition of OFC1 at 180°C ?

A. FeO
B. FeF_3
C. $FeCl_3$
D. $Fe_2(CO_3)_3$

8. In which of the following ways was the design of Experiment 1 different from that of Experiment 2 ? In Experiment 1:

   F. only OFC1 was studied; in Experiment 2, only OFC2 was studied.
   G. only OFC2 was studied; in Experiment 2, only OFC1 was studied.
   H. temperature was varied; in Experiment 2, temperature was always the same.
   J. temperature was always the same; in Experiment 2, temperature was varied.

9. In Experiment 1, during the decomposition of OFC2 at 100°C, as time increased from 0 to 998 sec, the pressure in the chamber:

   A. decreased from 0.20 atm to 0.01 atm.
   B. decreased from 0.01 atm to 0.20 atm.
   C. increased from 0.20 atm to 0.01 atm.
   D. increased from 0.01 atm to 0.20 atm.

10. A chemist claimed that under identical conditions, OFC2 will always break down in the presence of an MO more quickly than will OFC1. Are the results of Experiment 1 consistent with her claim?

    F. No; at each temperature tested, the induction period for OFC1 was less than that for OFC2.
    G. No; at each temperature tested, the induction period for OFC1 was greater than that for OFC2.
    H. Yes; at each temperature tested, the induction period for OFC1 was less than that for OFC2.
    J. Yes; at each temperature tested, the induction period for OFC1 was greater than that for OFC2.

11. Based on the information in the passage, which of the following could be the chemical formula for an OFC ?

    A. $CF_3(CF_2O)_{25}CF_3$
    B. $CF_3(CH_2CF_2O)_{45}CF_3$
    C. $CF_3(CF_2CO_2)_{15}CCl_3$
    D. $CF_3(CF_2OCF_2)_{35}CH_3$

Passage III

In *Zamia* (a genus of seed plants), males have pollen-producing cones, and females have seed-producing cones. Pollination requires the movement of pollen from inside a male cone to inside a female cone, where multiple *ovules* are located and pollinated. The ovules then develop into seeds. Two students discuss the pollination process.

Student 1

In *Zamia*, 90% of ovule pollinations result from insect pollination; 10% result from wind pollination. No other pollination mechanism exists.

Zamia have *mutualistic* (mutually beneficial) relationships with insects. *Weevils* (a type of beetle) swarm male *Zamia* cones when these cones are releasing pollen. Upon entering the cones, the weevils become covered with the plant's sticky pollen. The weevils then visit the female *Zamia* cones. In the absence of weevils, the percent of ovule pollination in *Zamia* is about 10%.

Wind pollination is infrequent because *Zamia* pollen is large and heavy. Additionally, the openings into the female cones are aligned horizontally, so wind-borne pollen must be blown horizontally to enter these cones.

Student 2

Wind pollination and insect pollination each cause 50% of pollination events in *Zamia* ovules. Without wind pollination, the percent of ovule pollination decreases by 50%. Likewise, without insect pollination, the percent of ovule pollination decreases by 50%. If neither of these processes occurs, the percent of ovule pollination decreases by 100%.

Wind tunnel experiments show that the shape of the female *Zamia* cones creates air currents that facilitate the horizontal movement of pollen into these cones. Additionally, male *Zamia* cones produce enormous quantities of pollen, a trait that is common only in wind-pollinated plants.

Experiments

The students proposed 3 experiments using a natural *Zamia* population in an area with weevils and in which the percent of ovule pollination is normally 99% (see the table).

Experiment	Procedure
1	Some female *Zamia* cones are covered with plastic bags that exclude insects and wind.
2	Some female *Zamia* cones are covered with mesh bags that exclude insects, but not wind.
3	Some female *Zamia* cones are covered with cylinders that exclude wind, but not insects.

12. Suppose Experiment 2 were performed as described. Based on Student 2's hypothesis, the percent of ovule pollination in the female *Zamia* cones that would be covered with mesh bags would be closest to:

F. 0%.
G. 10%.
H. 50%.
J. 99%.

13. Student 1 states that "wind-borne pollen must be blown horizontally to enter these cones." Which of the following describes how Student 2 responds to this statement? Student 2 argues that the shape of the:

A. female *Zamia* cones creates air currents that decrease the likelihood that pollen will enter these cones.
B. female *Zamia* cones creates air currents that increase the likelihood that pollen will enter these cones.
C. male *Zamia* cones creates air currents that decrease the likelihood that pollen will enter these cones.
D. male *Zamia* cones creates air currents that increase the likelihood that pollen will enter these cones.

14. Suppose an experiment were performed using a natural population of *Zamia* and that all of the male cones were covered with plastic bags that excluded insects and wind. Assuming that Student 1's hypothesis is correct, the percent of ovule pollination would most likely be closest to:

F. 0%.
G. 33%.
H. 67%.
J. 100%.

15. Student 1 would most likely agree with the statement that *Zamia* pollen is:

A. never present in the male *Zamia* cones.
B. not carried long distances by the wind.
C. produced in the female *Zamia* cones.
D. smaller than the pollen found in most plants.

16. With regard to the experiments described in the table, Students 1 and 2 would most likely agree that the percent of ovule pollination would be highest in female *Zamia* cones that are:

F. not covered with a bag or a cylinder.
G. covered with mesh bags that exclude insects.
H. covered with cylinders that exclude wind.
J. covered with plastic bags that exclude insects and wind.

17. Which of the following would most likely be used as a control group in Experiment 1 ?

A. Male *Zamia* cones that are covered with mesh bags
B. Male *Zamia* cones that are left uncovered
C. Female *Zamia* cones that are covered with mesh bags
D. Female *Zamia* cones that are left uncovered

18. Suppose the 3 experiments were performed as described. Student 2's hypothesis would be best supported if the percents of ovule pollination were the same for which of the following 2 groups of female *Zamia* cones?

F. Those in Experiment 1 that were covered with plastic bags and those in Experiment 1 that were not covered with plastic bags
G. Those in Experiment 1 that were covered with plastic bags and those in Experiment 2 that were covered with mesh bags
H. Those in Experiment 2 that were covered with mesh bags and those in Experiment 2 that were not covered with mesh bags
J. Those in Experiment 2 that were covered with mesh bags and those in Experiment 3 that were covered with cylinders

Passage IV

Three studies were conducted to investigate factors that affect wind erosion.

Study 1

Samples of 3 different soils (A–C) were collected from a study area and each was analyzed for sand, silt, and clay particle content and water content (see Table 1).

Table 1

Soil	Dry particle content (%)			Water content (%)
	sand	silt	clay	
A	79.8	11.7	8.5	2.9
B	67.1	18.1	14.8	6.8
C	17.6	33.2	49.2	21.3

Study 2

Another sample of each soil was dried in an oven for 24 hours, crushed, and passed through a screen with 0.84 mm openings. Each sample was used to fill its own 7 mm deep porous metal tray. Each tray was placed in a wind tunnel. A piece of white tape was placed at the down-wind end of the tray (see Figure 1).

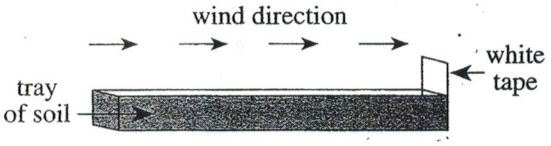


Figure 1

The wind speed was gradually increased until particles from the soil first began to collect on the white tape. This *threshold wind speed* was recorded for each sample.

The procedure described above was repeated, except that sand particles (an abrasive), which had been dyed green, were added at a constant rate to the moving air. The results are shown in Table 2.

Table 2

Oven-dried Soil	Threshold wind speed (m/sec)	
	no sand added	sand added
A	0.31	0.22
B	0.30	0.21
C	0.31	0.21

Study 3

A third sample of each soil was prepared as in Study 2. Each tray was placed in shallow water for 24 hours to saturate the sample. Each tray was then placed in the wind tunnel and exposed to an 8.5 m/sec wind. Once the wind had dried the top of the soil sample sufficiently, soil particles began to appear on the white tape. At that time, the water content of the top 1 mm of the soil sample was determined. This procedure was repeated 3 more times: first adding dyed sand to the 8.5 m/sec wind, then using a 13 m/sec wind, without and then with added sand. The results are shown in Figure 2.

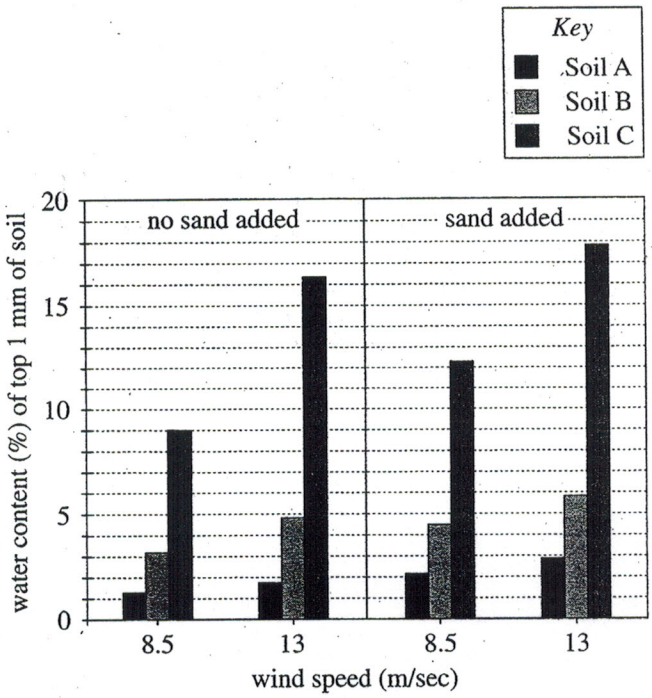


Figure 2

Tables and Figure 2 adapted from A. Selah and D. W. Fryrear, "Threshold Wind Velocities of Wet Soils as Affected by Wind Blown Sand." ©1995 by Williams and Wilkins.

19. It was hypothesized that soils with higher clay contents have typical water contents higher than those of soils with lower clay contents. Is this hypothesis consistent with the results of Study 1 ?

- **A.** Yes; as the clay content of the 3 soils increased, the water content decreased.
- **B.** Yes; as the clay content of the 3 soils increased, the water content also increased.
- **C.** No; as the clay content of the 3 soils increased, the water content decreased.
- **D.** No; as the clay content of the 3 soils increased, the water content also increased.

20. A fourth soil from the same study area was analyzed using the procedures described in Study 1 and was found to contain 73% sand, 15% silt, and 12% clay particles. A water content for that soil in which of the following ranges would be most consistent with the results of Study 1 ?

F. Less than 2.9%
G. Between 2.9% and 6.8%
H. Between 6.8% and 21.3%
J. Greater than 21.3%

21. Based on Study 1, the water content of Soil C immediately after being saturated for the 24 hours in Study 3 was most likely:

A. less than 1%.
B. between 1% and 5%.
C. between 5% and 15%.
D. greater than 15%.

22. Which of the following statements about the threshold wind speeds in the trials in which no dyed sand was added to the moving air is supported by the results of Study 2 for the 3 soils?

F. The threshold speed for Soil A was twice as high as the threshold wind speeds for the other 2 soils.
G. The threshold speed for Soil C was twice as high as the threshold wind speeds for the other 2 soils.
H. The threshold speeds for all 3 soils were approximately the same.
J. The threshold speeds for all 3 soils were all 0 m/sec.

23. Based on the results of Study 2 for a given soil, the addition of dyed sand to the moving air produced a threshold wind speed that was approximately:

A. one-third lower than the threshold wind speed when no sand was added to the moving air.
B. the same as the threshold wind speed when no sand was added to the moving air.
C. half again as high as the threshold wind speed when no sand was added to the moving air.
D. twice as high as the threshold wind speed when no sand was added to the moving air.

24. Suppose equal volumes of Soil A and Soil B were collected, thoroughly mixed, oven-dried for 24 hours, crushed, and passed through a screen as in Study 2. If this soil sample were then used in a repeat of Study 2 using added dyed sand, the threshold wind speed for this sample would most likely be between:

F. 0.10 m/sec and 0.15 m/sec.
G. 0.15 m/sec and 0.20 m/sec.
H. 0.20 m/sec and 0.25 m/sec.
J. 0.25 m/sec and 0.30 m/sec.

Passage V

A *capacitor* is a device used to store electrical charge. *Capacitance* is the amount of charge a capacitor can hold at a given voltage.

A student used the circuit shown in Figure 1 to perform 3 experiments.

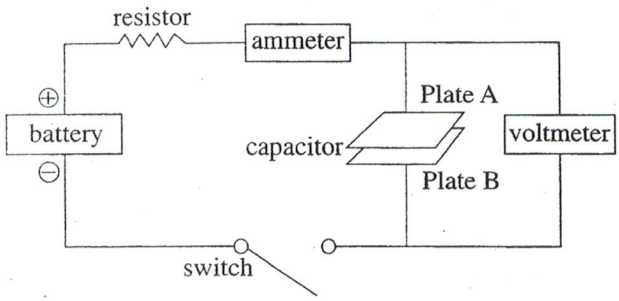


Figure 1

The *parallel-plate capacitor* consisted of 2 identical flat, parallel plates of copper, separated by a small distance (see Figure 2).

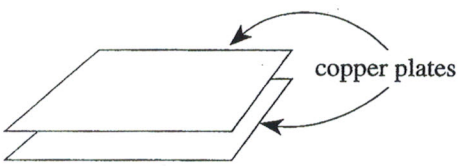


Figure 2

Initially, each plate of the capacitor was *uncharged.* (That is, each plate contained an equal number of positive charges and negative charges.) When the switch in the circuit was closed, *electrons* (negatively charged particles) flowed from Plate A of the capacitor through the ammeter, resistor, and battery to Plate B. After an amount of negative charge (Q) equaling -1×10^{-8} coulomb flowed to Plate B, the switch was reopened, and the voltage (V) in volts, between the charged plates was measured. Finally, the capacitance (C) was calculated in farads (F).

Experiment 1

Two square copper plates, each 0.05 m × 0.05 m (surface area 2.5×10^{-3} m^2), were separated by various thicknesses of air. The results are shown in Table 1.

Table 1

Plate separation (10^{-4} m)	V (volts)	C (10^{-11} F)
1	45.2	22.1
5	227	4.4
10	455	2.2

Experiment 2

Three pairs of square copper plates, each pair having a different surface area, were tested. Each pair was separated by a 1×10^{-4} m thickness of air. The results are shown in Table 2.

Table 2

Surface area of each plate (10^{-3} m^2)	V (volts)	C (10^{-11} F)
1	112	8.9
3	37.6	26.6
5	22.6	44.2

Experiment 3

The square copper plates from Experiment 1 were separated by a 1×10^{-4} m thickness of various materials. The number K is related to each material's suitability for use in a capacitor. The results are shown in Table 3.

Table 3

Material	K	V (volts)	C (10^{-11} F)
Mica	5.4	8.4	119
Water	80.4	0.56	1,780
Titanium dioxide	173	0.26	3,828

25. In Experiment 1, the voltage across the plates increased and the capacitance of the capacitor decreased as the:

A. surface area of the plates increased.
B. separation between the plates increased.
C. separation between the plates decreased.
D. number K of the material between the plates decreased.

26. In Experiment 2, the student varied which of the following properties of the capacitor?

F. Number K of the material between the plates
G. Surface area of the plates
H. Separation between the plates
J. Material composing the plates

27. Based on the results of the 3 experiments, the capacitor with which of the following combinations of separation, surface area per plate, and material will have the highest capacitance?

	Separation (m)	Surface area (m^2)	Material
A.	1×10^{-4}	1×10^{-3}	mica
B.	1×10^{-4}	1×10^{-3}	titanium dioxide
C.	1×10^{-4}	2×10^{-3}	titanium dioxide
D.	2×10^{-4}	1×10^{-3}	water

28. Assume that as K decreases, a material's suitability for use between the plates of a capacitor decreases. Based on the results of Experiment 3, which of the following correctly lists mica, water, and titanium dioxide in order of decreasing suitability for use between the plates of a capacitor?

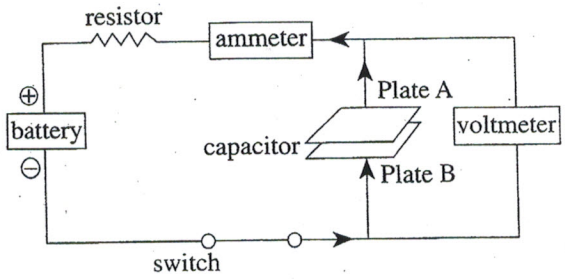
F. Mica, water, titanium dioxide
G. Mica, titanium dioxide, water
H. Titanium dioxide, water, mica
J. Titanium dioxide, mica, water

29. In each trial of Experiments 1–3, after the capacitor was charged and the switch opened, what was the charge on Plate A ?

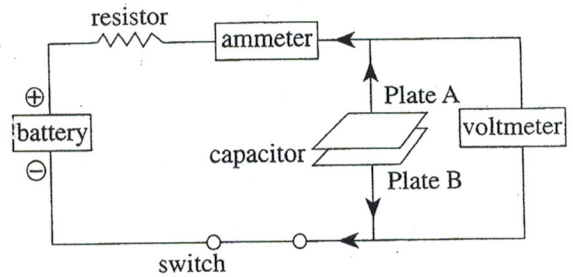
A. $+1 \times 10^{-8}$ coulomb
B. $+2 \times 10^{-8}$ coulomb
C. $+3 \times 10^{-8}$ coulomb
D. $+4 \times 10^{-8}$ coulomb

30. To charge the capacitor as described in the passage, the student caused electrons to flow in the direction(s) indicated by which of the following figures?

F.



G.



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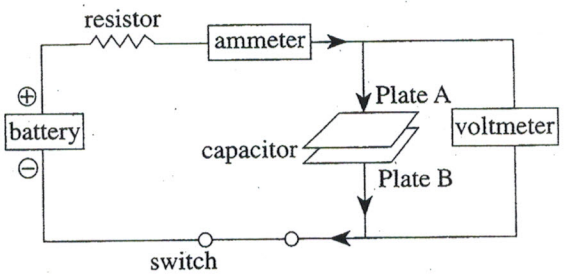
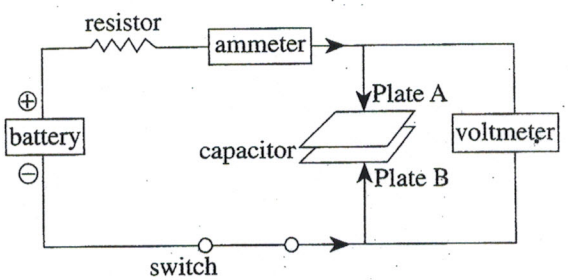


J.



Passage VI

When compounds dissolve in water, they either give off heat to, or absorb heat from, the solution. The transfer of heat (ΔH) is negative (*exothermic*) when heat is given off, or positive (*endothermic*) when heat is absorbed. Figure 1 shows the ΔH, in kilojoules per mole (kJ/mole, where 1 mole is 6×10^{23} molecules of any compound), when Compounds A or B dissolve in water at 25°C. *Solubility* is the maximum amount of a compound that will dissolve in a given volume of solvent. Figures 2 and 3 show how temperature affects the solubility (in moles/L) of Compounds A and B, respectively, in water.

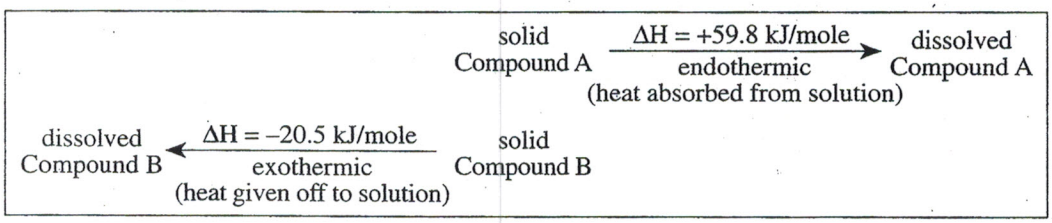


Figure 1

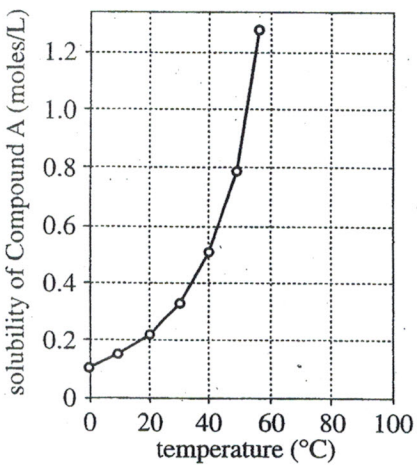


Figure 2

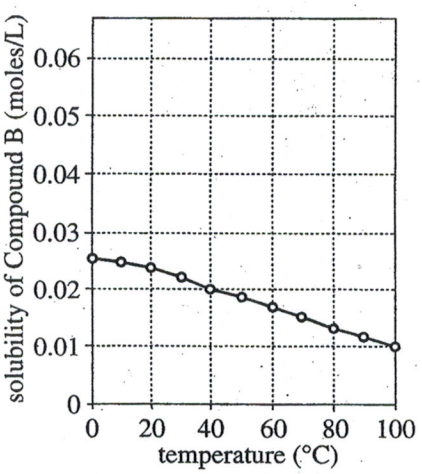


Figure 3

31. According to Figures 2 and 3, Compounds A and B have the same solubility at what temperature, if any?

A. 0°C
B. 35°C
C. 55°C
D. The solubilities are not equal at any temperature shown in the figures.

32. A solution is made that has a concentration of 1 mole/L of Compound A and 0.5 mole/L of Compound B. According to the passage, the number of molecules of Compound A in the solution is:

F. half the number of molecules of Compound B in the solution.
G. equal to the number of molecules of Compound B in the solution.
H. twice the number of molecules of Compound B in the solution.
J. 4 times the number of molecules of Compound B in the solution.

33. A chemist claimed that compounds that dissolve exothermically in water decrease in solubility as temperature increases. Is her claim supported by the data in Figures 1–3 ?

A. Yes; the solubility of Compound A decreased as temperature increased.
B. Yes; the solubility of Compound B decreased as temperature increased.
C. No; the solubility of Compound A increased as temperature increased.
D. No; the solubility of Compound B increased as temperature increased.

34. A chemist added either Compound A or Compound B to water at 25°C. The temperature of the solution decreased until the solution began to freeze. Based on the data in Figure 1, which compound did he most likely add to the water?

F. Compound A, because its ΔH is positive.
G. Compound A, because its ΔH is negative.
H. Compound B, because its ΔH is positive.
J. Compound B, because its ΔH is negative.

35. Ammonium nitrate is a compound that has a ΔH of +25.7 kJ/mole when it dissolves in water at 25°C. Based on the data in Figure 1, if 1 mole each of ammonium nitrate and Compound A are dissolved separately in equal amounts of water at 25°C, how will the transfer of heat compare?

A. Ammonium nitrate will absorb less heat from the solution than will Compound A.
B. Ammonium nitrate will absorb more heat from the solution than will Compound A.
C. Ammonium nitrate will give off less heat to the solution than will Compound A.
D. Ammonium nitrate will give off more heat to the solution than will Compound A.

Passage VII

Planets revolve around the Sun in elliptical orbits, as shown in Figure 1.

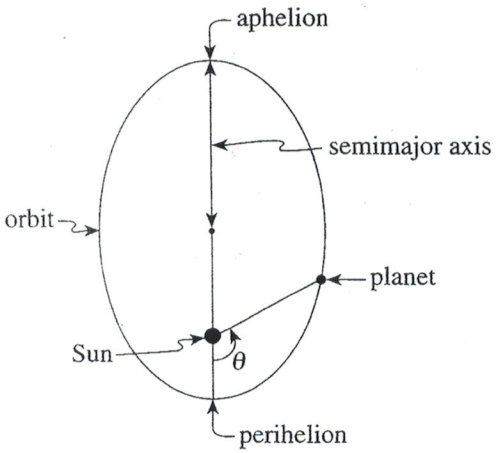


Figure 1

The *eccentricity* of an ellipse describes its elongation; the more elongated the ellipse, the greater its eccentricity. The semimajor axis is half the length of the ellipse.

Perihelion (Angle $\theta = 0°$) is the point on the orbit closest to the Sun; *aphelion* ($\theta = 180°$) is the point on the orbit farthest from the Sun. The speed of a planet varies with θ. The speed of a planet versus θ is shown in Figure 2 for orbits with various eccentricities and semimajor axes.

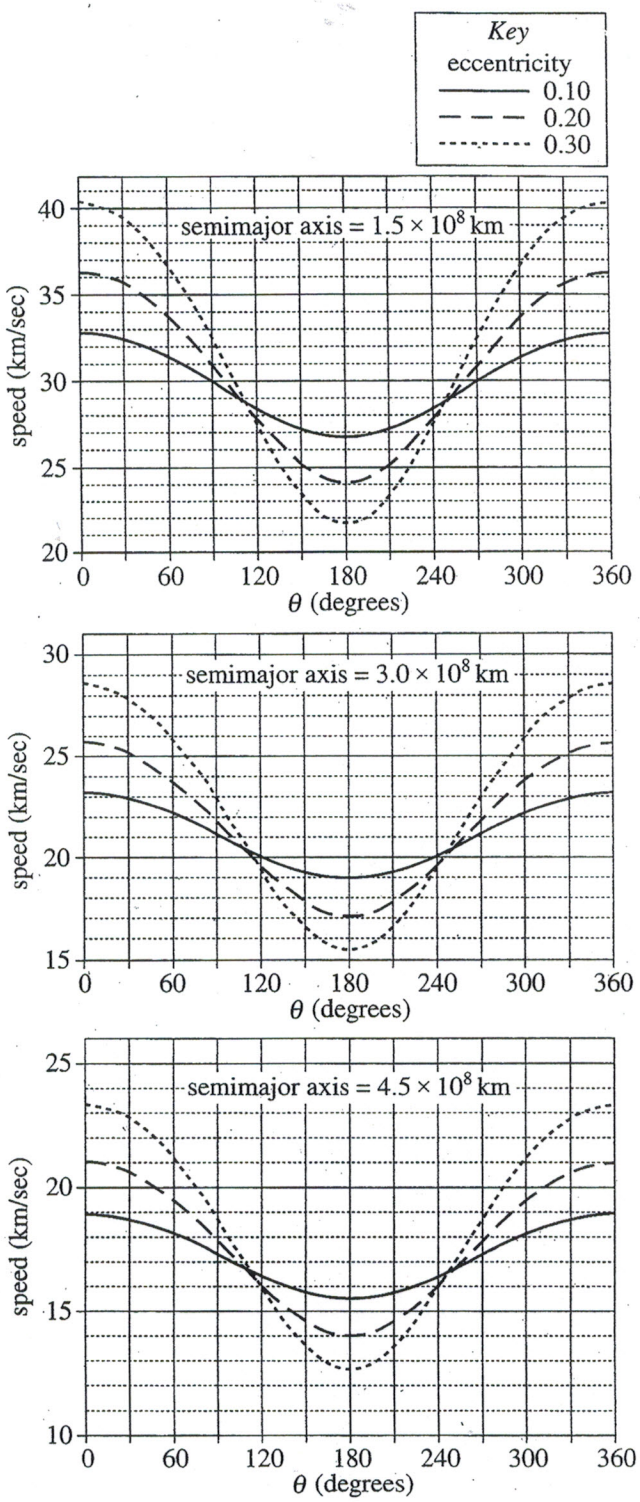


Figure 2

36. Consider a planet as it travels from $\theta = 0°$ to $\theta = 359°$ in an orbit with a semimajor axis of 1.5×10^8 km and an eccentricity of 0.10. Based on the data in Figure 2, how many times does the planet have a speed of 30 km/sec as it travels between those 2 angles?

F. One time
G. Two times
H. Three times
J. Four times

37. Based on the data in Figure 2, how does the speed of a planet change while it moves from perihelion to aphelion and while it moves from aphelion to perihelion?

	Perihelion to aphelion	Aphelion to perihelion
A.	speed increases	speed increases
B.	speed increases	speed decreases
C.	speed decreases	speed increases
D.	speed decreases	speed decreases

38. A planet will escape from the solar system if its orbital speed is greater than the *escape velocity*. Based on the data in Figure 2, if the semimajor axis is 1.5×10^8 km, the eccentricity is 0.10, and the escape velocity at perihelion is 44.2 km/sec, will the planet escape the solar system?

F. Yes, because the planet's orbital speed at perihelion is greater than the escape velocity.
G. Yes, because the planet's orbital speed at perihelion is less than the escape velocity.
H. No, because the planet's orbital speed at perihelion is greater than the escape velocity.
J. No, because the planet's orbital speed at perihelion is less than the escape velocity.

39. Based on the data in Figure 2, the orbital speed of a planet will most likely remain constant if the eccentricity of the planet's orbit is:

A. exactly 0.
B. between 0.1 and 0.5.
C. between 0.5 and 0.9.
D. exactly 1.

40. Based on the data in Figure 2, for a planet in an orbit around the Sun with a semimajor axis of 3.0×10^8 km and an eccentricity of 0.05, the speed at $\theta = 0°$ will be:

F. less than 23 km/sec.
G. between 23 km/sec and 26 km/sec.
H. between 26 km/sec and 28 km/sec.
J. greater than 28 km/sec.

END OF TEST 4

STOP! DO NOT RETURN TO ANY OTHER TEST.