PVPHS AVID Juniors
SAT/ACT Prep
2017/2018

STUDY HUT TUTORING

Assessment #7-8: ACT Science

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Assessment #7-8
ACT Science

Name: _____ **Date:** _____

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Homework:

Packet #7: ☐

Packet #8: ☐

Assessment:

Raw Score: _____/40

Percent: _____%

Converted Score: _____/36

Grade For Unit 7-8: _____/50*

*Automatic 100% if both packets complete and adequate work shown on assessment

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

When a substance dissolves in H_2O, heat is either absorbed from or given off to the solution. Experiments were done in which a known mass of a solute was added to a known mass of H_2O at a known initial temperature (T_i) in a closed, insulated container. When the maximum temperature change of the solution had occurred, the final temperature (T_f) was recorded. The maximum temperature change (ΔT) was then calculated as follows:

$$\Delta T = T_f - T_i$$

Figures 1 and 2 show the results for lithium chloride (LiCl) and ammonium nitrate (NH_4NO_3), respectively. In each trial, all of the solute completely dissolved.

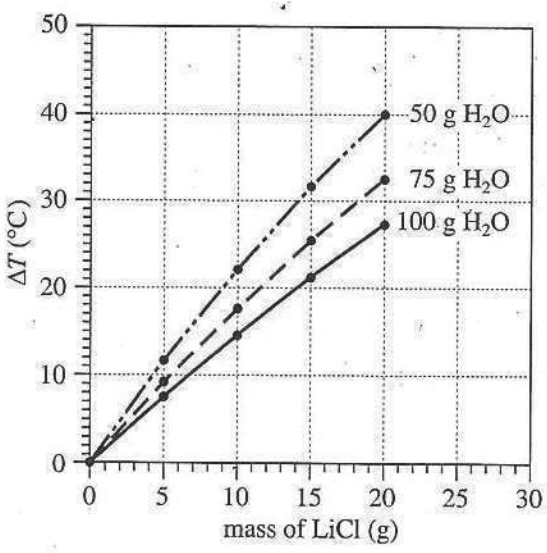

Figure 1

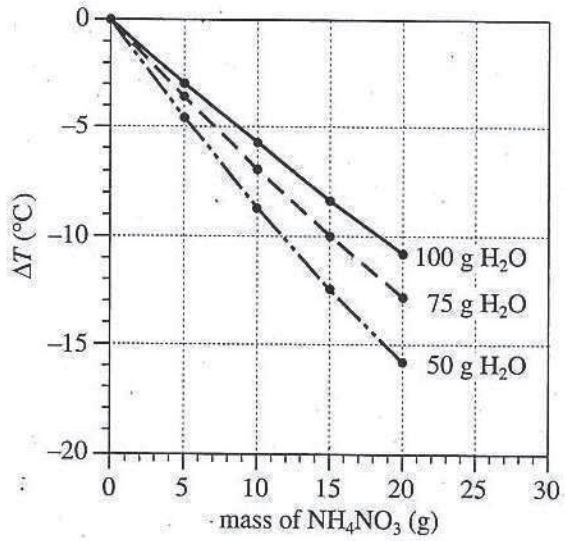

Figure 2

1. Based on Figure 1, when 5 g of LiCl was added to 50 g of H_2O, the temperature:
   - **A.** decreased, because heat was removed from the solution.
   - **B.** decreased, because heat was added to the solution.
   - **C.** increased, because heat was removed from the solution.
   - **D.** increased, because heat was added to the solution.

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2. Consider the trials represented in Figure 1 involving 20 g of LiCl. From trial to trial, as the LiCl concentration in the resulting solutions increased, the ΔT that was observed:

   F. increased only.
   G. increased, then decreased.
   H. decreased only.
   J. decreased, then increased.

3. If an additional trial had been done in which 25 g of LiCl had been added to 75 g of H_2O, ΔT would most likely have been:

   A. less than 20°C.
   B. between 20°C and 30°C.
   C. between 30°C and 40°C.
   D. greater than 40°C.

4. According to Figure 2, when 5 g of NH_4NO_3 was added to 100 g of H_2O, the temperature of the solution:

   F. decreased, because ΔT was positive.
   G. decreased, because ΔT was negative.
   H. increased, because ΔT was positive.
   J. increased, because ΔT was negative.

5. Based on Figures 1 and 2, which of the following combinations of a solute and H_2O at a known T_i would produce the greatest *increase* in temperature?

   A. 2 g of LiCl added to 5 g of H_2O
   B. 2 g of LiCl added to 10 g of H_2O
   C. 2 g of NH_4NO_3 added to 5 g of H_2O
   D. 2 g of NH_4NO_3 added to 10 g of H_2O

Passage II

During prophase I of meiosis, homologous chromosomes frequently exchange segments in a process called *crossing over*. As a result, genes on homologous chromosomes recombine, forming new allele combinations along chromosomes (see Figure 1).

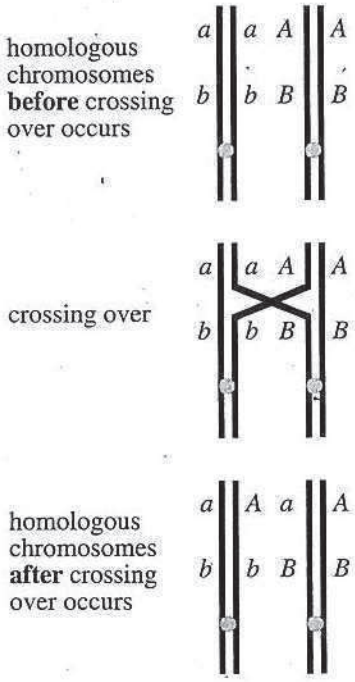

Figure 1

Because the frequency of recombination (RF) increases as the *map distance* (distance along a chromosome, in *map units* [mu]) between 2 genes increases, RF can be used to estimate the map distance between genes on a chromosome. However, as the map distance between 2 genes increases, the probability of multiple crossovers increases. Multiple crossovers decrease the apparent RF between 2 genes, resulting in RF values that underestimate map distance. To compensate for this effect, researchers use a mapping function to better estimate the map distance between 2 genes based on their RF (see Figure 2).

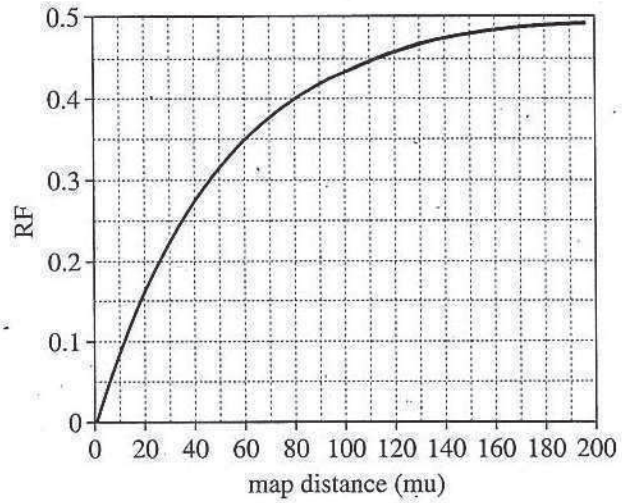

Figure 2

Four researchers performed a series of experiments to determine the RF for various pairs of genes on a chromosome. They then used the mapping function to determine the map distance between each pair. The results appear in Table 1.

Table 1

Genes	RF	Map distance (mu)
A and B	0.165	20
B and C	0.226	30
A and D	0.122	14

Each of the 4 researchers then proposed a model that is consistent with the results in Table 1. Each model shows how the genes might be located along the chromosome (see Figure 3). Each model correctly assumes the lengths of the genes are short enough that they can be ignored when calculating the map distance between genes.

Researcher	Model
1	D A B C
2	A D B C
3	D C A B
4	C A D B

Figure 3

Later, a fifth researcher working with the same chromosome and the same genes determined that the RF for Genes A and C is 0.091.

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6. All 4 models agree on the map distance between which of the following pairs of genes?

   F. Genes A and B
   G. Genes A and C
   H. Genes B and D
   J. Genes C and D

7. According to Figure 2, if 2 genes are separated by 70 mu, the RF of those 2 genes is most likely closest to which of the following?

   A. 0.377
   B. 0.477
   C. 0.577
   D. 0.677

8. If Researcher 2's model is correct and an additional gene, Gene G, is 8 mu from Gene B and 14 mu from Gene D, then Gene G is most likely between:

   F. Genes A and B.
   G. Genes A and D.
   H. Genes B and C.
   J. Genes B and D.

9. The result of the mapping experiment performed by the fifth researcher for Genes A and C is consistent with the models proposed by which 2 researchers?

   A. Researchers 1 and 3
   B. Researchers 1 and 4
   C. Researchers 2 and 3
   D. Researchers 3 and 4

10. Based on the information provided, crossing over occurs during the process that leads directly to the formation of which of the following?

    F. Neurons
    G. Skin cells
    H. Erythrocytes
    J. Gametes

11. Which researcher's model proposes that Genes C and D are separated by 64 mu ?

    A. Researcher 1's
    B. Researcher 2's
    C. Researcher 3's
    D. Researcher 4's

12. Genes R and T are separated by 10 mu on 1 chromosome. An organism has alleles *R* and *T* on 1 chromosome and alleles *r* and *t* on the homologous chromosome. If a single crossover occurred between these 2 genes as shown in Figure 1, the genotype of Genes R and T for the 2 chromatids involved in the crossover would be:

    F. *Rt* and *rT*.
    G. *RT* and *rt*.
    H. *Rr* and *Tt*.
    J. *RR* and *TT*.

Passage III

Pore water is water in the pores of subsurface material. Pore water chemistry in 2 wetlands—a *fen* and a *bog*—was studied during a 1990 summer drought and again the next summer, which had normal rainfall. The primary water supplies for fens and bogs are, respectively, groundwater and rainfall. Figure 1 shows the methane (CH_4) gas concentration in the pore water at various depths in the fen and the bog. Figures 2 and 3 show the pore water *conductivity* (which is directly proportional to the concentration of dissolved ions) and pH at various depths in the fen and the bog, respectively. Also shown are the locations of the water table, the *peat* (partially decomposed plant material) layer, and the mineral soil layer.

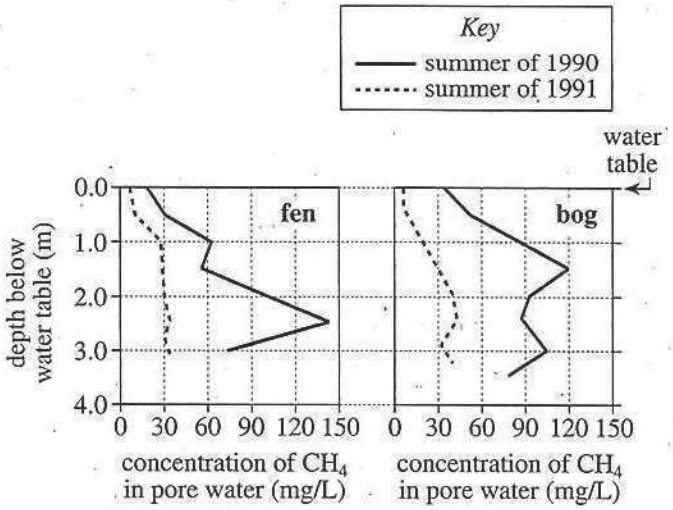
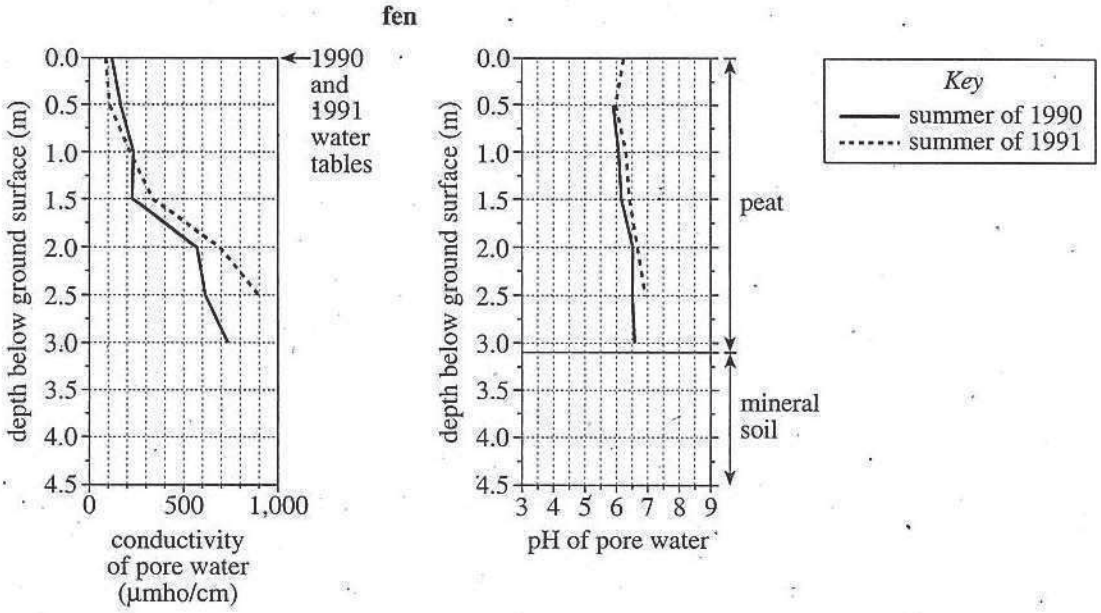


Figure 1



Note: Mineral soil is composed mainly of mineral matter.

Figure 2

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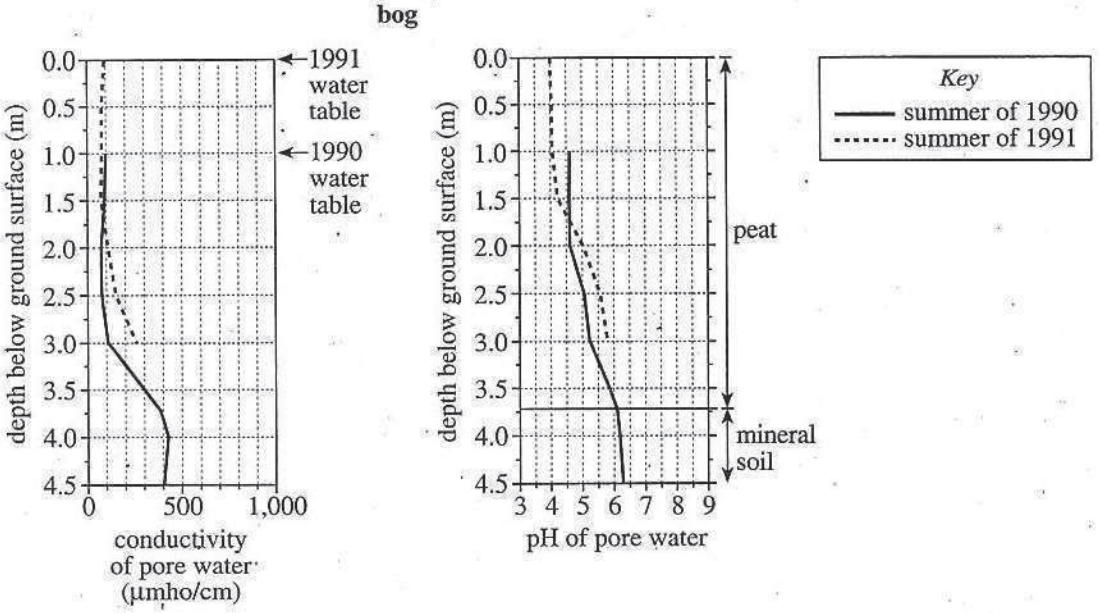

Note: Mineral soil is composed mainly of mineral matter.

Figure 3

Figures adapted from Edwin Romanowicz, Donald Siegel, and Paul Glaser, "Hydraulic Reversals and Episodic Methane Emissions During Drought Cycles in Mires." ©1993 by the Geological Society of America.

13. According to Figure 2, the conductivity of fen pore water in 1990 at a depth of 2.5 m was closest to which of the following?

- **A.** 350 μmho/cm
- **B.** 475 μmho/cm
- **C.** 600 μmho/cm
- **D.** 725 μmho/cm

14. Based on Figure 2, if the pH of pore water in the fen at a depth of 2.7 m had been measured in the summer of 1991, it would most likely have been closest to which of the following?

- **F.** 4.0
- **G.** 5.5
- **H.** 7.0
- **J.** 8.5

15. Which of the following is the most likely explanation for the difference in the depth of the bog water table in the 2 years?

- **A.** The amount of groundwater discharged to the bog was higher during the drought, and therefore the bog received more water than normal.
- **B.** The amount of groundwater discharged to the bog was higher during the drought, and therefore the bog received less water than normal.
- **C.** The amount of rainfall received by the bog was higher during the drought, and therefore the bog received more water than normal.
- **D.** The amount of rainfall received by the bog was lower during the drought, and therefore the bog received less water than normal.

16. If the data in Figures 2 and 3 are typical of fens and bogs in general, one would most likely make which of the following conclusions about the peat layer in a fen and in a bog?

- **F.** The peat layer in both a fen and a bog is completely above the water table at all times.
- **G.** The peat layer in both a fen and a bog is completely below the water table at all times.
- **H.** The peat layer in a fen is thicker than the peat layer in a bog.
- **J.** The peat layer in a fen is thinner than the peat layer in a bog.

17. According to Figure 1, the average concentration of CH_4 over the depths from 0.0 m to 3.0 m was higher during the summer of:

- **A.** normal rainfall than during the summer of drought in both wetlands.
- **B.** normal rainfall than during the summer of drought in the fen only.
- **C.** drought than during the summer of normal rainfall in both wetlands.
- **D.** drought than during the summer of normal rainfall in the bog only.

Passage IV

Atomic nuclei can be represented by the combination of symbols

$$^{A}_{Z}X$$

where Z is the number of protons in a nucleus of Element X, and A (equal to Z plus the number of neutrons) is the mass number of the same nucleus. For example, $^{12}_{6}C$ represents a nucleus of carbon containing 6 protons and 6 neutrons; $^{14}_{6}C$ represents a nucleus of a different *isotope* (type) of carbon that contains 6 protons and 8 neutrons.

Atomic nuclei undergo 3 types of radioactive decay. Particles emitted during the 3 types of decay are listed in Table 1. Figure 1 shows a sequence of radioactive decays, called the *uranium series*, that begins with the decay of $^{238}_{92}U$.

Table 1

Type of radioactive decay	Particle emitted	Symbol of emitted particle
Alpha	helium nucleus	$^{4}_{2}He$
Beta	electron	e^{-}
Gamma	gamma ray photon	γ

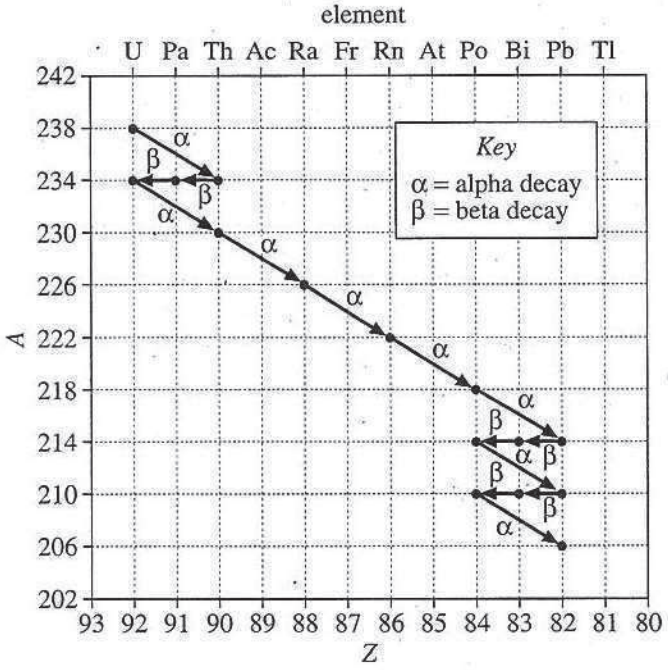

Figure 1

18. Which of the following symbols correctly represents the isotope of radium (Ra) that is part of the radioactive decay sequence plotted in Figure 1 ?

F. $^{88}_{226}Ra$
G. $^{226}_{226}Ra$
H. $^{88}_{88}Ra$
J. $^{226}_{88}Ra$

19. How many neutrons, if any, does a nucleus of the isotope of helium listed in Table 1 contain?

A. 0
B. 1
C. 2
D. 3

20. Based on Figure 1, if a nucleus of $^{230}_{90}Th$ underwent beta decay, which of the following nuclei would be produced?

F. $^{230}_{230}Pa$
G. $^{230}_{91}Pa$
H. $^{230}_{91}Th$
J. $^{91}_{231}Th$

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21. A sample of spent nuclear reactor fuel contains a mixture of a uranium isotope, $^{235}_{92}U$, and a plutonium isotope, $^{239}_{94}Pu$. Based on Table 1 and Figure 1, if one of the isotopes is produced by the radioactive decay of the other isotope, which of the following best explains how the mixture was formed?

A. $^{235}_{92}U$ underwent alpha decay, producing $^{239}_{94}Pu$.
B. $^{239}_{94}Pu$ underwent alpha decay, producing $^{235}_{92}U$.
C. $^{235}_{92}U$ underwent beta decay, producing $^{239}_{94}Pu$.
D. $^{239}_{94}Pu$ underwent beta decay, producing $^{235}_{92}U$.

22. Suppose the $^{4}_{2}He$ nucleus emitted during an alpha decay and the e^- emitted during a beta decay have the same kinetic energy. Which of the 2 particles is moving at the higher speed?

F. The $^{4}_{2}He$ nucleus, because it is more massive than the e^-.
G. The $^{4}_{2}He$ nucleus, because it is less massive than the e^-.
H. The e^-, because it is more massive than the $^{4}_{2}He$ nucleus.
J. The e^-, because it is less massive than the $^{4}_{2}He$ nucleus.

Passage V

Size exclusion chromatography (SEC) is used to separate the components of a solution of polymer molecules. In SEC a sample solution of polymer molecules is injected into a flow of solvent. The sample is then carried through a column filled with beads that contain microscopic pores (see Figure 1).

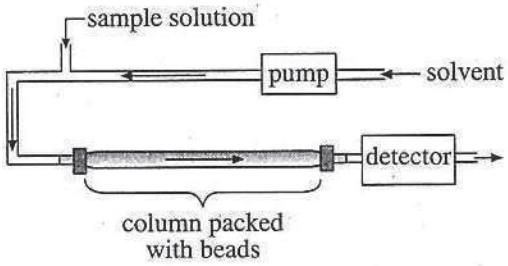

Figure 1

Smaller molecules easily diffuse into the pores. Larger molecules do not as easily diffuse into the pores, or are larger than the pores. Therefore, smaller molecules spend more time in the column than do larger molecules, causing the components of the mixture to separate. As solvent containing a component of the mixture exits the column through the detector, a peak is plotted versus time (starting from injection). The portion of solvent corresponding to a peak is called a *fraction*. The time corresponding to the top of a peak is the fraction's *retention time* (RT). The RT corresponds to the *average molecular mass* (AMM) of the molecules in that fraction. The shape of the peak reflects the distribution of molecular masses of the molecules in the fraction.

Experiment 1

Polystyrene is a polymer made up of identical subunits. Five types of polystyrene (P1–P5) were dissolved together in a solvent. The AMM of P1–P5 is given in Table 1. The range of molecular masses for each of P1–P5 was ±100 amu of the AMM.

Table 1

Polystyrene	AMM (amu*)
P1	800
P2	4,000
P3	10,000
P4	50,000
P5	200,000

*amu = atomic mass unit

A sample of the solution was injected into an SEC apparatus. Each fraction was analyzed as it exited the apparatus (see Figure 2).

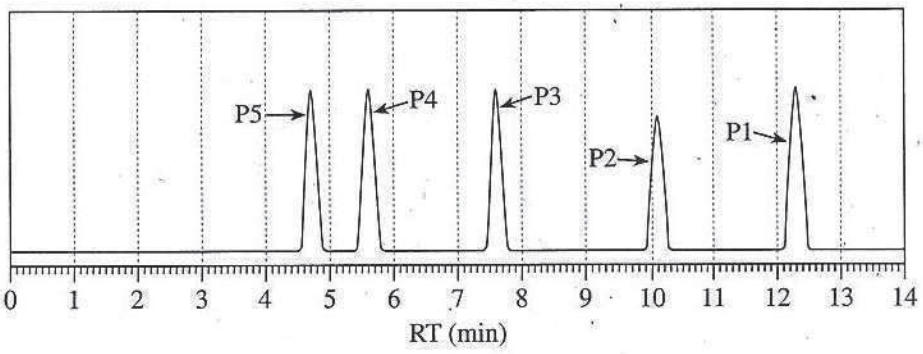

Figure 2

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Experiment 2

Chemists used 3 different methods to synthesize polystyrenes, forming polystyrene mixtures M1, M2, and M3, respectively. Each of M1–M3 was then analyzed as in Experiment 1 (see Figure 3).

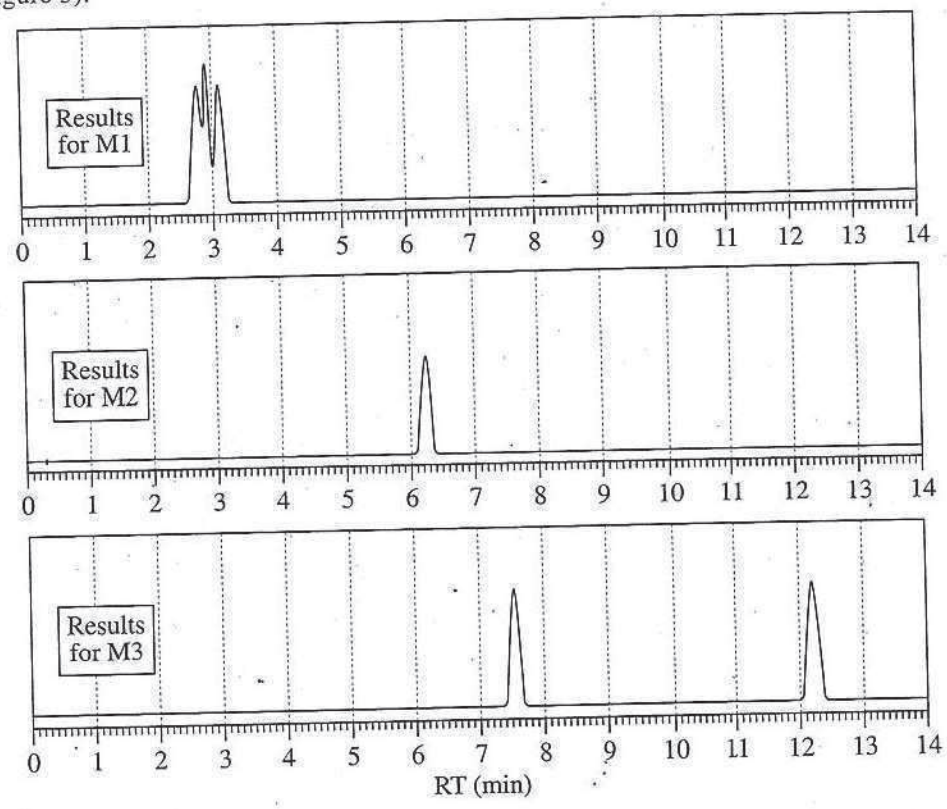

Figure 3

23. Based on the results of Experiments 1 and 2, M3 is most likely which polymer(s) from Experiment 1 ?

A. P1 only
B. A mixture of P1 and P3 only
C. A mixture of P3 and P5 only
D. A mixture of P2, P4, and P5 only

24. In Experiment 1, the molecules of which of the following polymers spent the longest amount of time in the column?

F. P1
G. P2
H. P4
J. P5

25. Based on the results of Experiments 1 and 2, which of the following ranks P4, P5, and M2 from smallest AMM to largest AMM ?

A. P4, P5, M2
B. P5, M2, P4
C. M2, P4, P5
D. M2, P5, P4

26. In Experiment 1, on average, did P3 molecules or P4 molecules more easily diffuse into the pores of the beads while in the column of the SEC apparatus?

F. P3 molecules, because they have a larger AMM.
G. P3 molecules, because they have a smaller AMM.
H. P4 molecules, because they have a larger AMM.
J. P4 molecules, because they have a smaller AMM.

27. In which, if any, of the mixtures synthesized for Experiment 2 is the average mass of the molecules in the mixture most likely greater than 200,000 amu ?

A. M1
B. M2
C. M3
D. Neither M1, M2, nor M3

28. How does the number of molecules in a 1 g sample of P2 compare to the number of molecules in a 1 g sample of P4 ? The number of P2 molecules is:

F. less, because P2 has a larger AMM than does P4.
G. less, because P2 has a smaller AMM than does P4.
H. greater, because P2 has a larger AMM than does P4.
J. greater, because P2 has a smaller AMM than does P4.

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Passage VI

Two studies examined how forest fires would have burned during the late Paleozoic era, when Earth's atmosphere contained an elevated O_2 content of more than 21% by volume.

Araucaria tree leaves and *Pinus* tree *dowels* (wood pieces) and needles, all from modern trees, were used in the studies to most closely model trees in Paleozoic forests.

Study 1

A 10 mg sample of *Araucaria* leaves was heated at a rate of 40°C/min in an atmosphere containing 21% O_2 by volume. The mass of the sample was measured every 2 sec during heating. These procedures were repeated in a second trial in an atmosphere containing 35% O_2 by volume. Then each trial was repeated using a 10 mg sample of paper instead of *Araucaria* leaves (see Figure 1). The rate of mass loss was directly proportional to the rate of combustion.

Study 2

In each of several trials, a 75 cm long chamber was filled either with dowels or needles, both from a *Pinus* tree. Each sample of dowels or needles had been dried and then soaked in water to bring it to the desired water content by weight. A mixture of O_2 gas and N_2 gas was continuously supplied to the chamber. The sample was ignited at 1 end of the chamber.

For any trial in which the sample burned completely, the flame spread rate was recorded. Those trials represented conditions under which a forest fire would have burned out of control. A *failed burn* (F) was recorded for any trial in which the fire in the chamber extinguished itself before the sample burned completely (see Table 1).

Table 1

Water content of:		Flame spread rate (cm/min) in an atmosphere containing:			
		16% O_2	21% O_2	28% O_2	35% O_2
Dowels	2%	2.48	2.76	3.92	5.00
	12%	F	1.45	2.49	3.09
	23%	F	F	F	2.73
	61%	F	F	F	F
Needles	2%	18.75	20.69	37.50	39.30
	12%	17.24	19.43	22.61	28.08
	23%	F	15.00	18.22	22.86
	61%	F	F	F	F

Note: % O_2 was by volume.

Figure and table adapted from Richard Wildman et al., "Burning of Forest Materials under Late Paleozoic High Atmospheric Oxygen Levels." ©2004 by the Geological Society of America.

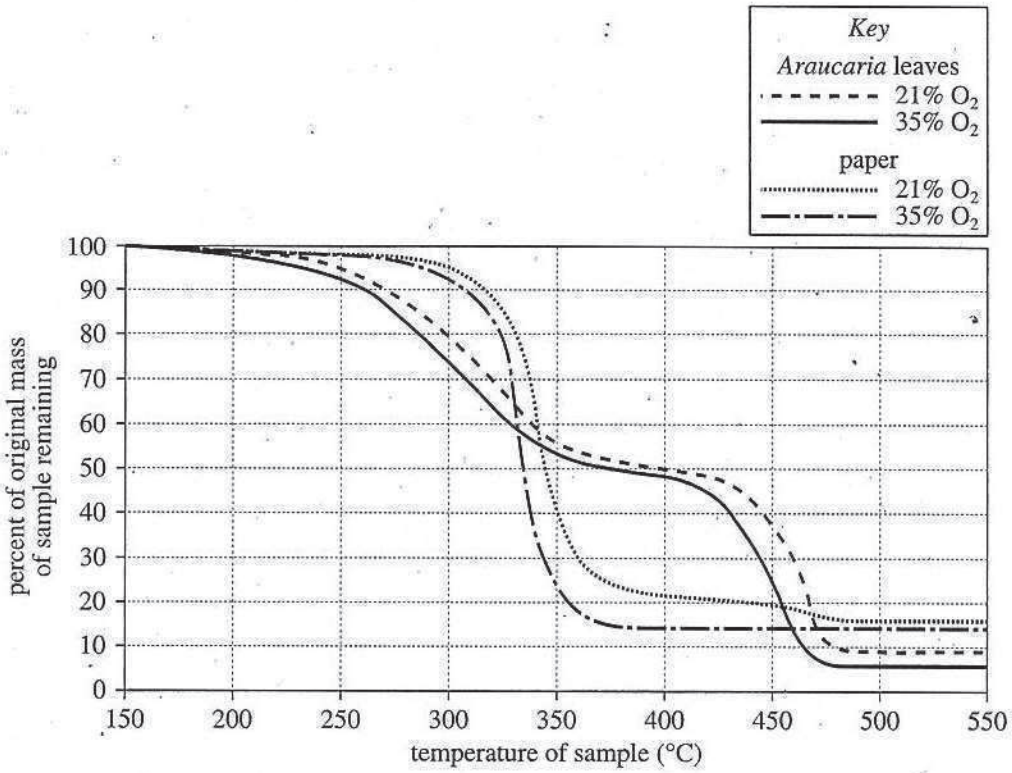

Figure 1

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29. According to the results of Study 2, as O_2 content increased from 16% to 35%, the flame spread rate for dowels having a water content of 2%:

A. increased only.
B. increased, then decreased.
C. decreased only.
D. decreased, then increased.

30. According to the results of Study 1, the sample of *Araucaria* leaves heated in an atmosphere containing 35% O_2 lost mass most rapidly over which of the following temperature ranges?

F. 275°C to 325°C
G. 325°C to 375°C
H. 375°C to 425°C
J. 425°C to 475°C

31. Suppose that the needles and wood of a type of tree that existed in the late Paleozoic era and closely resembled modern *Pinus* trees had water contents above 65% by weight. Based on Study 2, would a tree of that type have burned completely in an atmosphere containing 28% O_2 by volume and in an atmosphere containing 35% O_2 by volume, respectively?

	28% O_2	35% O_2
A.	No	Yes
B.	No	No
C.	Yes	No
D.	Yes	Yes

32. Suppose that in an additional trial in Study 2, needles having a water content of 10% by weight had been burned in an atmosphere containing 28% O_2 by volume. Based on the results of Study 2, the flame spread rate recorded for that trial would most likely have been:

F. less than 18.22 cm/min.
G. between 18.22 cm/min and 22.61 cm/min.
H. between 22.61 cm/min and 37.50 cm/min.
J. greater than 37.50 cm/min.

33. Consider a Paleozoic forest fire burning out of control in a stand of trees that closely resembled modern *Pinus* trees. Based on the results of Study 2 for an atmosphere containing 28% O_2 and an atmosphere containing 35% O_2, is it more likely that the *crown fire* (fire spreading through the live foliage of trees) or the *surface fire* (fire spreading through the trees just above the ground) would have spread faster?

A. The crown fire, because the flame spread rates for needles were much lower than the corresponding rates for dowels.
B. The crown fire, because the flame spread rates for needles were much higher than the corresponding rates for dowels.
C. The surface fire, because the flame spread rates for needles were much lower than the corresponding rates for dowels.
D. The surface fire, because the flame spread rates for needles were the same as the corresponding rates for dowels.

34. In Study 1, the paper sample heated in an atmosphere containing 21% O_2 had lost approximately what percent of its original mass by the time the temperature reached 350°C ?

F. 20%
G. 40%
H. 60%
J. 80%

Passage VII

Students studied the trajectories of a baseball launched under a variety of conditions.

Study 1

On a flat plain during a windless day, students launched a baseball using the launcher shown in Figure 1.

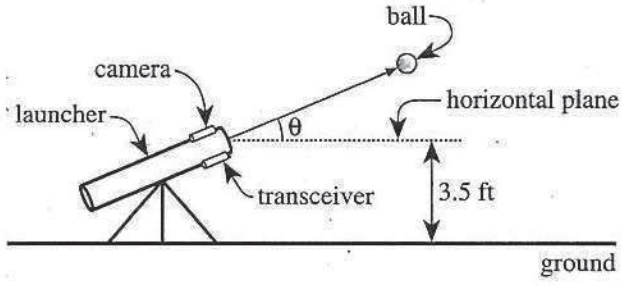

Figure 1

A camera mounted on the launcher always pointed in the direction of the ball's launch. A radar *transceiver* (transmitter-receiver) was also mounted on the launcher.

As the ball moved along its path, Angle θ, which is defined in Figure 1, continuously varied. The variation in θ was monitored by the camera, which recorded the ball's image in its viewfinder every 0.5 sec after launch until the ball landed. For each recorded image, θ was found (see Figure 2).

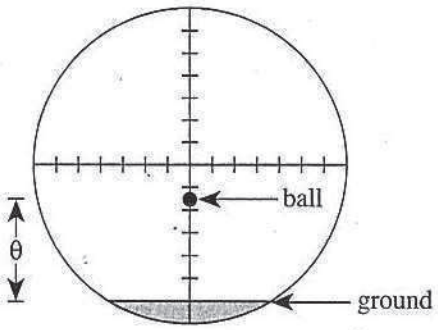

Figure 2

In addition, every 0.5 sec after launch, the transceiver emitted a radar pulse, part of which was reflected back to the transceiver by the ball. The round-trip travel time of each pulse was recorded and then used to determine the distance, D, between the transceiver and the ball (see Figure 3).

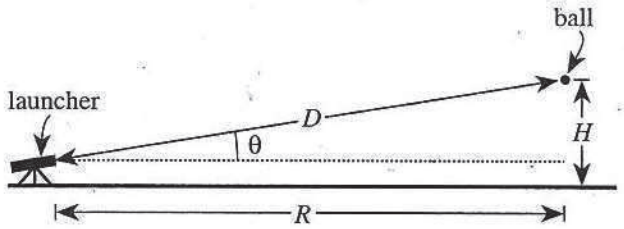

Figure 3

Using D and θ, the students found the ball's height, H, and distance, R, at the end of each 0.5 sec interval. H was plotted versus R, and a smooth curve was fitted to the data points.

This procedure was followed for launches of the ball at speeds of 80 mph, 90 mph, 100 mph, 110 mph, and 120 mph. For each launch speed, the ball was launched at $\theta = 35°$. The curves representing the 5 launch speeds were connected by lines drawn through the data points representing H and R for time = 2 sec, 3 sec, 4 sec, and 5 sec after launch (see Figure 4).

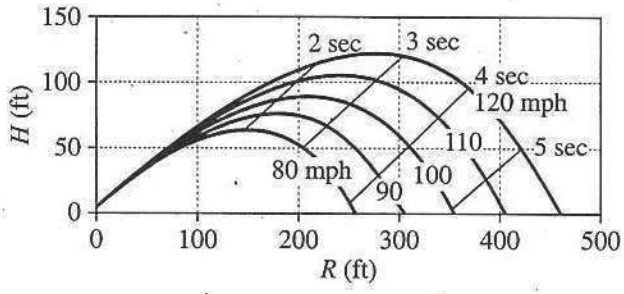

Figure 4

Figure 4 adapted from Robert K. Adair, *The Physics of Baseball*, 3rd ed. ©2002 by Robert K. Adair.

GO ON TO THE NEXT PAGE.

Study 2

Using a mathematical model, the students calculated H and R at 0.5 sec intervals for the same ball launched under the same conditions as in Study 1, except that they assumed that air was absent. The results are plotted in Figure 5.

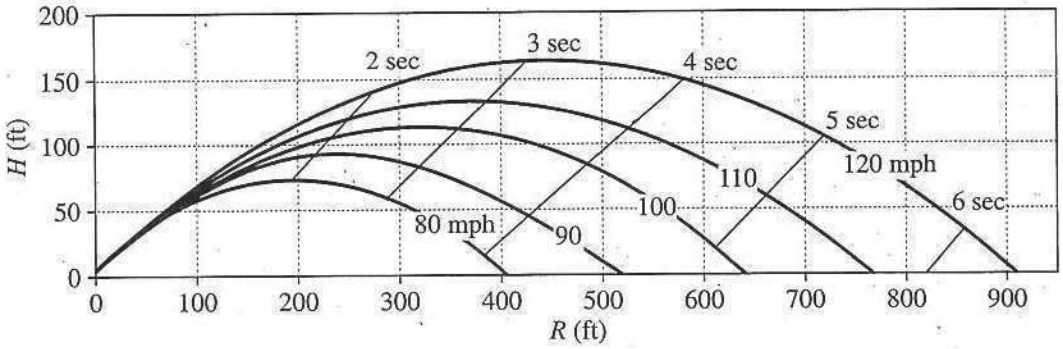

Figure 5

35. Suppose the ball were launched at 35° in the absence of air from a height of 3.5 ft. Based on Figure 5, the ball would land approximately how many feet farther from the launcher if it were launched at 100 mph than if it were launched at 90 mph ?

A. 50 ft
B. 100 ft
C. 500 ft
D. 600 ft

36. While the ball was in flight, how frequently did the camera record the ball's image?

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

37. Fenway Park, home of baseball's Boston Red Sox, has a wall in left field that is 37 ft high. The distance measured along the left field line from home plate to the bottom of the wall is 310 ft. Assume that, on a windless day, a ball identical to the one used in Experiment 1 leaves a bat at an initial height of 3.5 ft above the ground, at an angle of 35° with respect to the horizontal, and flies straight along the left field line. The ball will fly over the wall if the ball leaves the bat at which of the speeds given in Figure 4 ?

A. 120 mph only
B. 110 mph or 120 mph only
C. 100 mph, 110 mph, or 120 mph only
D. Any of the speeds given in Figure 4

38. Based on Figure 4, as the launch speed was increased, how did H and R at 3 sec after launch vary?

	H	R
F.	increased	increased
G.	increased	decreased
H.	decreased	increased
J.	decreased	decreased

39. Based on Figure 5, if the ball were launched in the absence of air from a height of 3.5 ft at 120 mph and $\theta = 35°$, how long would the ball most likely be in flight from the moment it was launched to the moment it landed?

A. Between 4 sec and 5 sec
B. Between 5 sec and 6 sec
C. Between 6 sec and 7 sec
D. Between 7 sec and 8 sec

40. Based on Figure 3, if c represents the speed of light, how long did it take each radar pulse to make the round-trip between the transceiver and the ball?

F. $2\frac{D}{c}$

G. $\frac{R}{c}$

H. $2\frac{c}{D}$

J. $\frac{c}{R}$

END OF TEST 4

STOP! DO NOT RETURN TO ANY OTHER TEST.