Chapter 7

Science Practice Test

SCIENCE TEST

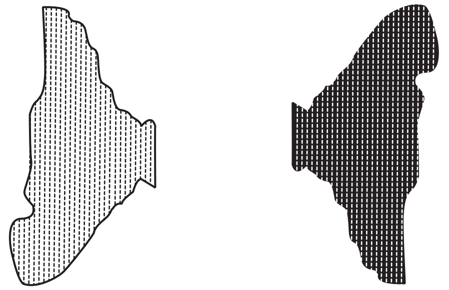
35 Minutes–40 Questions

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

Moth body coloration (see Figure 1) is a *hereditary* trait that can be passed from organisms to their offspring.



white body coloration

black body coloration

Figure 1

Scientists studied the body coloration of 2 subspecies of moths, *Biston betularia f. typica* and *Biston betularia f. carbonaria*. Both species live in City X. Only *B. betularia f. typica* lives in City Y, while only *B. betularia f. carbonaria* lives in City Z. Both subspecies live on trees found in temperate climates, such as birch. Moths with light body coloration are camouflaged from predators while living on light-colored trees but are not hidden in heavily polluted areas where the tree bark is darkened. Moths with dark body coloration are camouflaged from predators on trees that are darkened by pollution but not on light-colored trees.

Study 1

Scientists captured 100 *B. betularia f. typica* and 100 *B. betularia f. carbonaria* in City X. They labeled each one, recorded its color, and released it. Then they calculated the percent of moths having each of the body color intensities on a scale of 1 to 10, with 1 being completely white and 10 being completely black. The researchers followed the same methods with 100 *B. betularia f. typica* moths from City Y and 100 *B. betularia f. carbonaria* moths from City Z. The results of this study are shown in Figures 2–4.

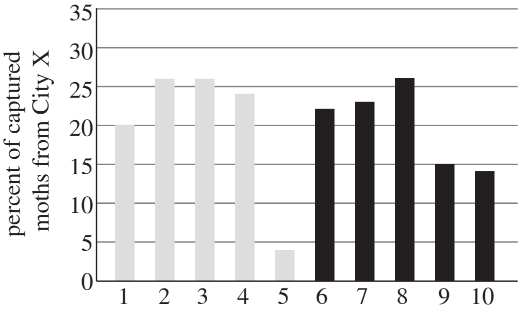


Figure 2

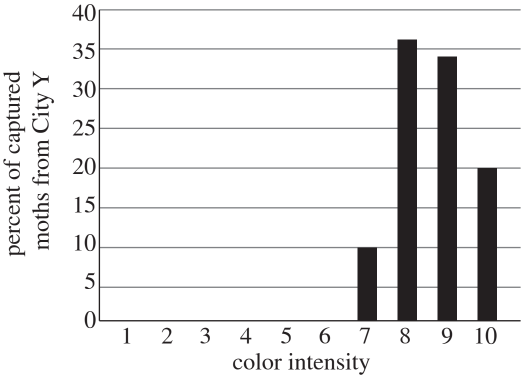


Figure 3

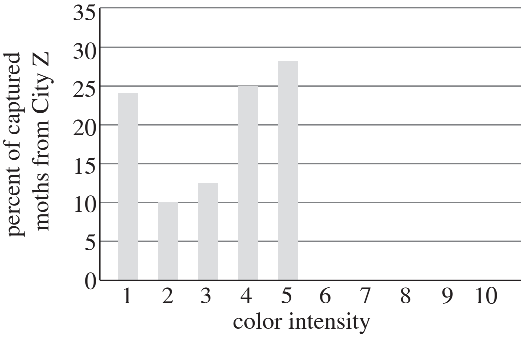


Figure 4

Study 2

After the end of Study 1, the scientists returned to City Y over the course of 10 years, from 1996–2005. During each visit, they captured at least 50 *B. betularia f. typica* moths and measured their body color intensities. They then calculated the average *B. betularia f. typica* body color intensity from the 1–10 scale for each of the 10 years. The scientists noted that during the 10-year period, 3 years were particularly wet, while 2 years were especially dry (see Figure 5). During wet years, pollutants tend to be washed from the surfaces of tree bark. During dry years, pollutants are more likely to concentrate on tree bark, and the tree bark itself tends to become thicker.

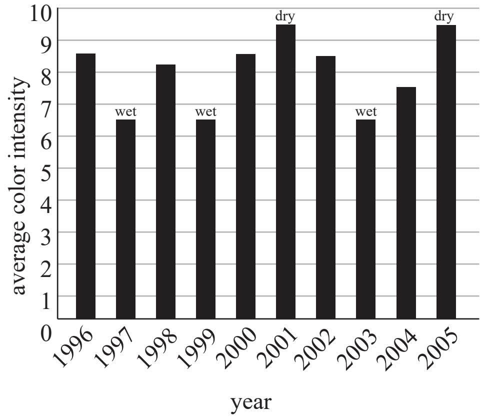


Figure 5

1. Based on the results from Study 1, the largest percentage of moths in City Y and City Z had a color intensity of:

	City Y	City Z
A.	8	1
B.	8	5
C.	9	4
D.	9	5

2. During which of the following years was birch bark most likely to be thickest in City Y ?

- **F.** 2000
- **G.** 2001
- **H.** 2002
- **J.** 2003

3. How was Study 1 different from Study 2 ?

- **A.** *B. betularia f. carbonaria* moths were captured in Study 1 but not in Study 2.
- **B.** *B. betularia f. typica* moths were captured in Study 1 but not in Study 2.
- **C.** The moth body coloration was measured in Study 1 but not in Study 2.
- **D.** The moth body coloration was measured in Study 2 but not in Study 1.

4. The scientists most likely labeled the moths in Study 1 to:

- **F.** determine how body coloration was affected by pollution in City X.
- **G.** determine the average wingspan of each population of moths.
- **H.** make sure that the body coloration of each moth was measured only once.
- **J.** make sure that the body coloration of each moth was measured multiple times.

5. Based on the results from Study 2, would a moth with a body color intensity measuring 6.5 or a moth with a body color intensity measuring 9.5 have had a greater chance of surviving in 2005 ?

- **A.** A moth with a body color intensity of 6.5, because pollutants concentrate more on tree bark during dry years.
- **B.** A moth with a body color intensity of 6.5, because pollutants are removed from tree bark during dry years.
- **C.** A moth with a body color intensity of 9.5, because pollutants concentrate more on tree bark during dry years.
- **D.** A moth with a body color intensity of 9.5, because pollutants are removed from tree bark during dry years.

6. A scientist hypothesized that there would be a greater range in body coloration in the *B. betularia f. typica* moths when they are forced to coexist with another subspecies of moths. Do the results from Study 1 support this hypothesis?

- **F.** Yes; the range of body coloration for *B. betularia f. typica* moths was greater in City X than in City Y.
- **G.** Yes; the range of body coloration for *B. betularia f. typica* moths was greater in City Y than in City X.
- **H.** No; the range of body coloration for *B. betularia f. typica* moths was greater in City X than in City Y.
- **J.** No; the range of body coloration for *B. betularia f. typica* moths was greater in City Y than in City X.

7. Based on the information in the passage, would the moth population in City Z have most likely been higher in wet years or dry years?

- **A.** Wet, because the trees are darker and provide better camouflage.
- **B.** Wet, because the trees are lighter and provide better camouflage.
- **C.** Dry, because the trees are darker and provide better camouflage.
- **D.** Dry, because the trees are lighter and provide better camouflage.

Passage II

Ions in seawater, such as Cl$^-$, SO$_4^{2-}$, Na$^+$, and Mg^{2+}, are carried down to the ocean floor through a process known as *marine deposition*. SO$_4^{2-}$ and Mg^{2+} primarily come from the erosion of rocks, while Cl$^-$ and Na$^+$ come from both mineral erosion and underwater volcanoes and hydrothermal vents.

Study 1

A fluid motion sensor was placed on a section of the seabed in the Atlantic Ocean, and data were collected over 12 months. At 6:00 a.m. every morning, the movement of water past the sensor was recorded, and a small amount of water was sequestered. Figure 1 shows the movement of water in millions of cubic meters (m^3) per second.

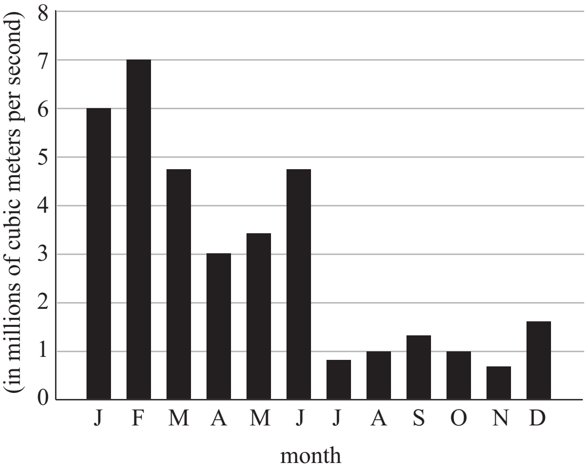
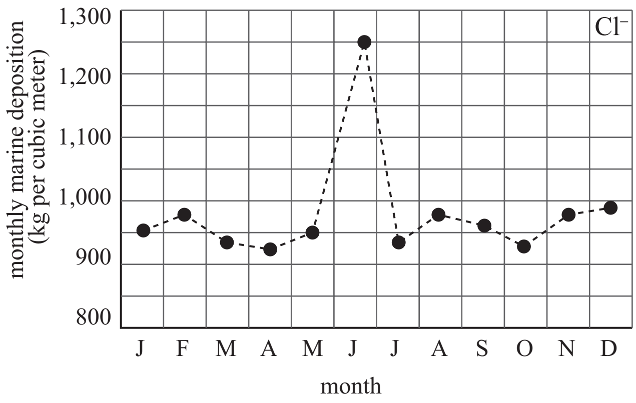


Figure 1

At the end of each month, the sequestered water was extracted by a scientific research crew, and a portion was analyzed for the concentrations of Cl$^-$ and SO$_4^{2-}$ ions. Using these data, the marine deposition was measured in kilograms (kg) per cubic meter (m^3) for each substance in each month (see Figure 2).



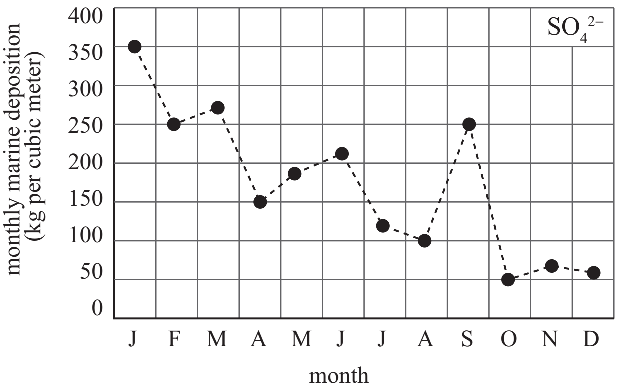


Figure 2

Study 2

Another portion of the monthly water sample was analyzed for concentrations of Na$^+$ and Mg^{2+} ions. The monthly marine deposition was calculated for each substance in equivalents (Eq) per m^3 (see Figure 3).

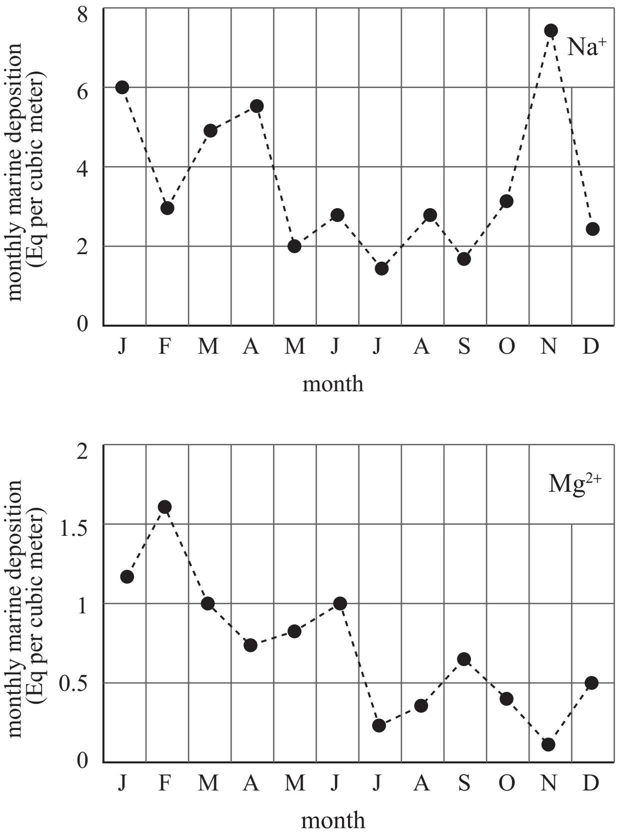


Figure 3

Study 3

The annual marine deposition of Cl^- and SO_4^{2-} ions over the 12-month period was calculated in kg/m^3 at the test site in the Atlantic Ocean, and also at two sites in the Arctic Ocean, located 2,000 and 4,000 kilometers due north, respectively (see Figure 4).

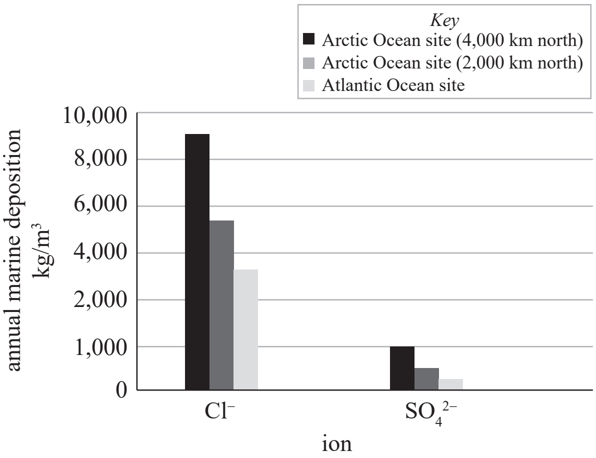


Figure 4

8. Based on the results from Study 1, the mean monthly marine deposition for Cl^- over the year of the study was:

F. less than 900 kg/m^3.
G. between 900 kg/m^3 and 1,100 kg/m^3.
H. between 1,100 kg/m^3 and 1,200 kg/m^3.
J. greater than 1,200 kg/m^3.

9. A student states, "The marine deposition of Na^+ is highest in the winter and lowest in the summer, since the winter features greater activity of volcanoes and hydrothermal vents." Is this statement supported by the results of Study 2 ?

A. No, because marine deposition of Na^+ was, on average, greater between November and January than it was between June and August.
B. No, because marine deposition of Na^+ was, on average, less between November and January than it was between June and August.
C. Yes, because marine deposition of Na^+ was, on average, greater between November and January than it was between June and August.
D. Yes, because marine deposition of Na^+ was, on average, less between November and January than it was between June and August.

10. Suppose that the study was repeated with the sensor placed in an underwater cave in the Atlantic Ocean where there is no movement of water. The information provided indicates that during this new study, the researchers would have measured:

F. no marine deposition of any of the 4 substances.
G. no marine deposition of Cl^- and SO_4^{2-}, but a high level of marine deposition of Na^+ and Mg^{2+}.
H. high marine deposition of Cl^- and SO_4^{2-}, but no marine deposition of Na^+ and Mg^{2+}.
J. high marine deposition of all 4 substances.

11. According to Study 3, as the distance from the fluid motion sensor in the Atlantic Ocean decreases, the annual marine deposition:

A. decreases for both Cl^- and SO_4^{2-}.
B. decreases for Cl^- but increases for SO_4^{2-}.
C. increases for Cl^- but decreases for SO_4^{2-}.
D. increases for both Cl^- and SO_4^{2-}.

12. Which of the following variables remained constant in Study 2 ?

F. Marine deposition of SO_4^{2-}
G. Marine deposition of Mg^{2+}
H. Movement of water during the month
J. Location of the study

13. According to Figure 1, during the year over which data were collected, the movement of water was greatest in February and least in November. According to Figures 2 and 3, the marine deposition of which ion was also greatest in February and least in November?

A. Cl^-
B. Mg^{2+}
C. Na^+
D. SO_4^{2-}

14. In Study 3, the marine deposition of Cl^- at a site 1,500 km due north of the Atlantic Ocean test site would most likely have been:

F. less than 500 kg/m^3.
G. between 500 and 1,000 kg/m^3.
H. between 3,000 and 5,000 kg/m^3.
J. greater than 5,000 kg/m^3.

Passage III

Oxidation-reduction titration is a method in which precise volumes of a *titrant* (an oxidizing or reducing agent) are added dropwise to a known volume of an *analyte* (a reducing or oxidizing agent, respectively, if the titrant is the oxidizing or reducing agent). This process can be monitored by adding a *redox indicator* (a substance that changes color over a certain range of electrode potentials) to the analyte or by measuring the sample's *voltage* using a potentiometer. Voltage (measured in kilovolts, kV) is a measure of the force of an electrical current that could be transmitted by the solution.

Two titration experiments were performed at 298 K using a 0.10 *M* iodine (I_2) solution and either a 0.0010 *M* sulfur dioxide (SO_2) solution or a 0.0010 *M* sodium thiosulfate solution (where *M* is the number of moles of oxidizing or reducing agent per liter of solution). All solutions were aqueous. A redox indicator solution of *starch* was also used. When iodine reacts with sulfur dioxide or sodium thiosulfate, the iodine is reduced to 2 iodide ions (I^-) and the sulfur dioxide or sodium thiosulfate is oxidized. Once the sulfur dioxide or sodium thiosulfate is fully oxidized, any additional iodine in the solution will bind with the starch and form a complex with a deep blue color.

Experiment 1

A drop of starch solution was added to an Erlenmeyer flask containing 100.0 mL of the sulfur dioxide solution. A potentiometer, which acts as a control input for electronic circuits, was placed in the solution. The I_2 solution was incrementally added to the sulfur dioxide solution. After each addition, the sulfur dioxide solution was stirred and the solution's color and voltage were recorded (see Figure 1).

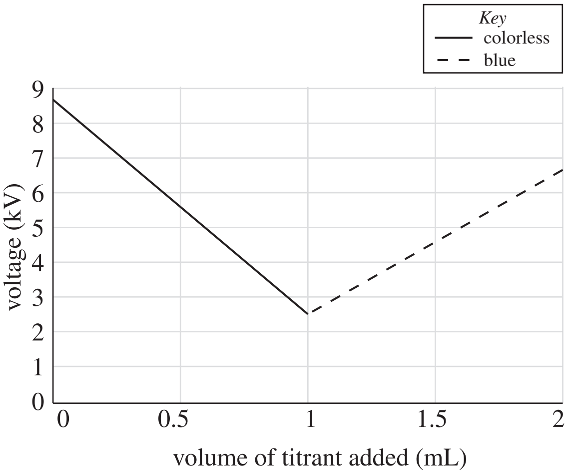


Figure 1

Experiment 2

Experiment 1 was repeated, except that the sodium thiosulfate solution was used instead of the sulfur dioxide solution (see Figure 2).

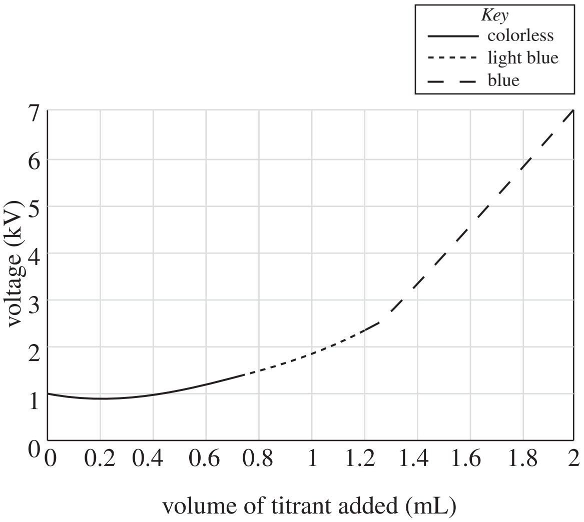


Figure 2

15. Suppose that in Experiment 1, the volume of sulfur dioxide solution used was 120.0 mL instead of 100.0 mL. Based on the information in the passage, how much titrant would need to be added before the solution turned blue?

- **A.** Less than 0.5 mL
- **B.** Between 0.5 mL and 1.0 mL
- **C.** Exactly 1.0 mL
- **D.** Between 1.0 mL and 1.5 mL

16. In Experiment 1, the analyte was blue at which of the following volumes of titrant added?

- **F.** 0.1 mL
- **G.** 0.5 mL
- **H.** 0.9 mL
- **J.** 1.5 mL

17. In Experiment 2, the analyte was in its fully oxidized form for which of the following volumes of titrant added?

A. 0.3 mL
B. 0.6 mL
C. 0.9 mL
D. 1.2 mL

18. In Experiment 1, if 2.5 mL of titrant was added to the analyte, the voltage would most likely have been:

F. less than 1 kV.
G. between 1 kV and 4 kV.
H. between 4 kV and 7 kV.
J. greater than 7 kV.

19. In Experiment 2, which solution was the analyte and which solution was the titrant?

	Titrant	Sample solution
A.	Sodium thiosulfate	I_2
B.	Sulfur dioxide	I_2
C.	I_2	Sodium thiosulfate
D.	I_2	Sulfur dioxide

20. In Experiments 1 and 2, the potentiometer that was placed in the analyte most likely did which of the following?

F. Detected the concentration of starch in the solution
G. Conducted an electric current initiated by ions in the solution
H. Heated the solution to its boiling point
J. Cooled the solution to its freezing point

21. A chemist states that in Experiment 2, the analyte was fully oxidized with 0.2 mL of titrant added, but not with 1.8 mL of titrant added. Do the results of Experiment 2 support this claim?

A. Yes; at a value of 0.2 mL of titrant added, the analyte was blue, while at a value of 1.8 mL of titrant added, the analyte was colorless.
B. Yes; at a value of 0.2 mL of titrant added, the analyte was colorless, while at a value of 1.8 mL of titrant added, the analyte was blue.
C. No; at a value of 0.2 mL of titrant added, the analyte was blue, while at a value of 1.8 mL of titrant added, the analyte was colorless.
D. No; at a value of 0.2 mL of titrant added, the analyte was colorless, while at a value of 1.8 mL of titrant added, the analyte was blue.

Passage IV

An astrophysics class is given the following facts about the burning out of stars.

1. The burning out of a star can be divided into 3 stages: *helium fusion*, *planetary nebula formation*, and *white dwarf development*.
2. Mid-sized stars fuse hydrogen nuclei (composed of protons) into helium nuclei at their centers, in a process known as helium fusion. These include yellow dwarves, like our Sun, and the slightly smaller orange dwarves. Helium fusion releases a significant amount of kinetic energy.
3. As kinetic energy continues to be released, a planetary nebula may form, in which colorful, ionized gas spreads out from the star's center.
4. The remaining material at the center of the planetary nebula condenses into a white dwarf, which is relatively cool and small in size.
5. Red dwarves are smaller stars that can also carry out helium fusion. These stars can develop into white dwarves sooner than yellow and orange dwarves, and they do not form planetary nebulas.

Two students discuss the eventual fate of three stars in the Alpha Centauri system: Alpha Centauri A, a 1.10-solar-mass yellow dwarf star, where one *solar mass* unit is equivalent to the mass of the Sun; Alpha Centauri B, a 0.91-solar-mass orange dwarf star; and Alpha Centauri C, a 0.12-solar-mass red dwarf star. Alpha Centauri A and B comprise a binary star system that revolves around a common center of mass, while Alpha Centauri C revolves around a nearby center of mass.

Student 1

The 3 stars of the Alpha Centauri system all formed at the same time from the same collection of matter. Alpha Centauri C was initially the most massive of the three stars, and Alpha Centauri A and Alpha Centauri B had the same size. The large Alpha Centauri C had more helium fusion than the other two stars, so it quickly became the smallest of the stars. More of its matter flowed to Alpha Centauri A than to Alpha Centauri B, making Alpha Centauri A slightly larger than Alpha Centauri B.

Student 2

Alpha Centauri A and Alpha Centauri B formed at a different time than Alpha Centauri C. Alpha Centauri A and Alpha Centauri B formed at the same time from a common collection of matter, and Alpha Centauri A was initially more massive than Alpha Centauri B. Alpha Centauri C formed later from a different, smaller collection of matter and never became bigger than a red dwarf. At some point, the small Alpha Centauri C was attracted to the other two stars, resulting in a triple star system.

22. Based on Student 2's discussion, Alpha Centauri C is part of the Alpha Centauri system because of which of the following forces exerted on Alpha Centauri C by the original binary star system?

F. Electromagnetism
G. Gravitation
H. Strong nuclear interaction
J. Weak nuclear interaction

23. Based on Student 1's discussion and Fact 2, while matter flowed between Alpha Centauri C and Alpha Centauri A, Alpha Centauri C released most of its energy by fusing:

A. helium nuclei into hydrogen nuclei at its core.
B. hydrogen nuclei into helium nuclei at its core.
C. helium nuclei into hydrogen nuclei at its periphery.
D. hydrogen nuclei into helium nuclei at its periphery.

24. Suppose that stars that form from the same collection of matter have similar chemical composition, but stars that form from different collections of matter have different chemical compositions. Student 2 would most likely agree with which of the following statements comparing chemical compositions of the stars in the current Alpha Centauri system at the time that they were formed?

F. Alpha Centauri A and Alpha Centauri B had the most similar compositions.
G. Alpha Centauri A and Alpha Centauri C had the most similar compositions.
H. Alpha Centauri B and Alpha Centauri C had the most similar compositions.
J. Alpha Centauri A, Alpha Centauri B, and Alpha Centauri C all had the same compositions.

25. If the mass of the Sun is 2.0×10^{30} g, what is the mass of Alpha Centauri A ?

A. 1.8×10^{30} g
B. 2.0×10^{30} g
C. 2.2×10^{30} g
D. 2.4×10^{32} g

26. Which of the following statements best explains why the process described in Fact 2 requires a high initial temperature and pressure?

F. All electrons are negatively charged, and like charges attract each other.
G. All electrons are negatively charged, and like charges repel each other.
H. All protons are positively charged, and like charges attract each other.
J. All protons are positively charged, and like charges repel each other.

27. Based on Fact 5, which of the three stars, if any, in the Alpha Centauri system would Student 1 expect to most likely develop into a white dwarf first?

A. Alpha Centauri A
B. Alpha Centauri B
C. Alpha Centauri C
D. The three stars will likely develop into white dwarves at the same time.

28. Based on Fact 5, would Student 2 agree that by the time Alpha Centauri B develops into a white dwarf, it will have spent as much time as a mid-sized star as Alpha Centauri A ?

F. Yes, because according to Student 2, Alpha Centauri A has always been less massive than Alpha Centauri B.
G. Yes, because according to Student 2, Alpha Centauri A has always been more massive than Alpha Centauri B.
H. No, because according to Student 2, Alpha Centauri A has always been less massive than Alpha Centauri B.
J. No, because according to Student 2, Alpha Centauri A has always been more massive than Alpha Centauri B.

Passage V

Three experiments were conducted using the gases nitrogen (N_2), nitrogen dioxide (NO_2), and xenon (Xe). For each gas:

1. A cap was placed on a 2 L metal chamber, containing sensors to measure temperature and pressure and a valve to allow gas to enter.
2. Air was pumped out of the chamber until the pressure inside was measured to be 0.00 mmHg.
3. The chamber was placed on an analytical balance, which was then reset to 0.00 g.
4. A specific mass of gas was added to the chamber.
5. When the gas in the vessel reached room temperature (298 K), the mass and pressure inside were recorded.
6. Steps 4 and 5 were repeated for different masses.

The experiments were repeated using a 4 L metal chamber (see Figures 1 and 2).

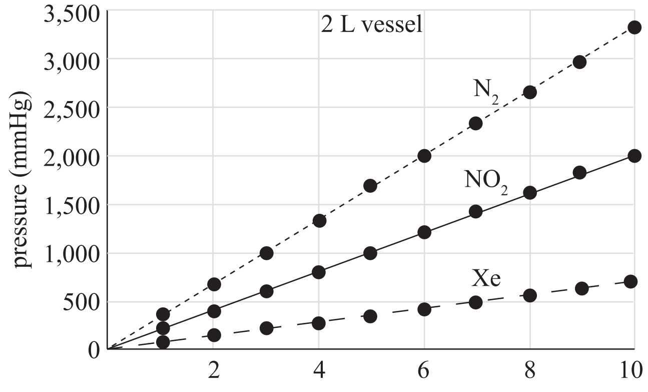


Figure 1

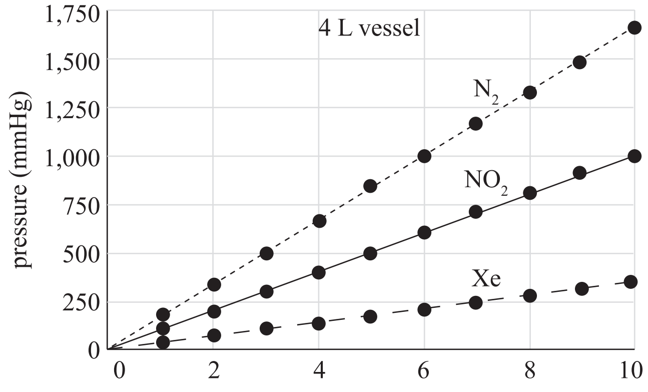


Figure 2

29. Based on Figure 2, if 12 g of Xe had been added to the 4 L vessel, the pressure would have been:

A. less than 300 mmHg.
B. between 300 and 600 mmHg.
C. between 600 mmHg and 900 mmHg.
D. greater than 1,200 mmHg.

30. Suppose the experiments had been repeated, except with a 3 L vessel. Based on Figures 1 and 2, the pressure exerted by 10 g of NO_2 would most likely have been:

F. less than 1,000 mmHg.
G. between 1,000 and 2,000 mmHg.
H. between 2,000 and 2,500 mmHg.
J. greater than 2,500 mmHg.

31. Based on Figures 1 and 2, for a given mass of N_2 at 298 K, how does the pressure exerted by the N_2 in a 4 L vessel compare to the pressure exerted by the N_2 in a 2 L vessel? In the 4 L vessel, the N_2 pressure will be:

A. half as great as in the 2 L vessel.
B. the same as in the 2 L vessel.
C. twice as great as in the 2 L vessel.
D. 4 times as great as in the 2 L vessel.

32. Which of the following best explains why equal masses of N_2 and NO_2 at the same temperature and in vessels of the same size had different pressures? The pressure exerted by the N_2 was:

F. greater, because there were fewer N_2 molecules per gram than there were NO_2 molecules per gram.
G. greater, because there were more N_2 molecules per gram than there were NO_2 molecules per gram.
H. less, because there were fewer N_2 molecules per gram than there were NO_2 molecules per gram.
J. less, because there were more N_2 molecules per gram than there were NO_2 molecules per gram.

33. Suppose the experiment involving N_2 and the 4 L vessel had been repeated, except at a temperature of 287 K. For a given mass of N_2, compared to the pressure measured in the original experiment, the pressure measured at 287 K would have been:

A. greater, because pressure is directly proportional to temperature.
B. greater, because pressure is inversely proportional to temperature.
C. less, because pressure is directly proportional to temperature.
D. less, because pressure is inversely proportional to temperature.

34. Figure 3 shows the molar masses of N_2, NO_2, and Xe.

Gas	Molar Mass (g/mol)
N_2	28.0
NO_2	46.0
Xe	131.3

Figure 3

The molar mass of O_2 is approximately 32 g/mol. Suppose that 6 grams of O_2 were placed into the 4 L chamber using the same procedure described in steps 1–6. Which of the following is most likely closest to the pressure of the O_2 at 298 K ?

F. 610 mmHg
G. 870 mmHg
H. 1,530 mmHg
J. 1,780 mmHg

Passage VI

The *absolute threshold pressure for hearing* is the minimum air pressure at each audio frequency that can produce a sound that is detectable by the human ear. The *pain threshold pressure for hearing* is the maximum air pressure at each audio frequency that the human ear can withstand without sensing pain.

Figure 1 below displays the absolute and pain threshold pressures for hearing in two media: air and water. The figure also shows *P*, the percentage increase in compression of the air or water with increasing sound pressure. Audio frequency is given in cycles per second (cyc/sec), and sound pressure level is given in decibels (db).

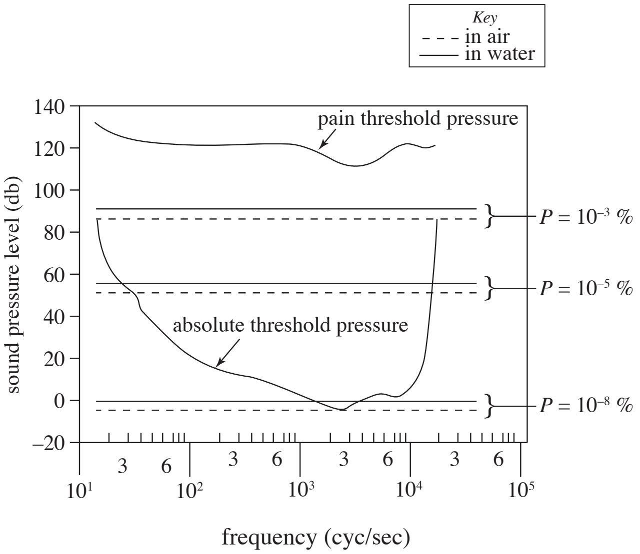


Figure 1

35. At which of the following frequencies can humans hear the widest range of sound pressure levels without pain?

A. 20 cyc/sec
B. 400 cyc/sec
C. 2,500 cyc/sec
D. 20,000 cyc/sec

36. According to Figure 1, which of the following is the closest to the highest frequency that can be heard by a human being?

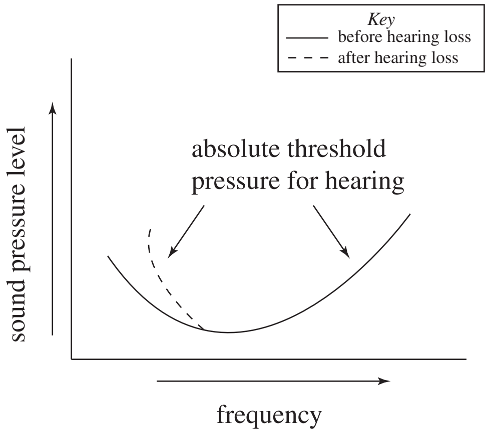
F. 20 cyc/sec
G. 200 cyc/sec
H. 2,000 cyc/sec
J. 20,000 cyc/sec

37. Based on Figure 1, a sound of a given frequency will have the highest sound level pressure for which of the following sets of conditions?

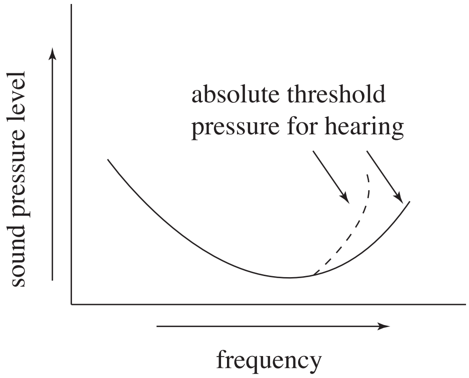
	Sound in	*P*
A.	Air	10^{-8}%
B.	Air	10^{-3}%
C.	Water	10^{-8}%
D.	Water	10^{-3}%

38. As humans grow older, there is often a loss in the ability to hear sounds at high frequencies. Which of the following figures best illustrates this?

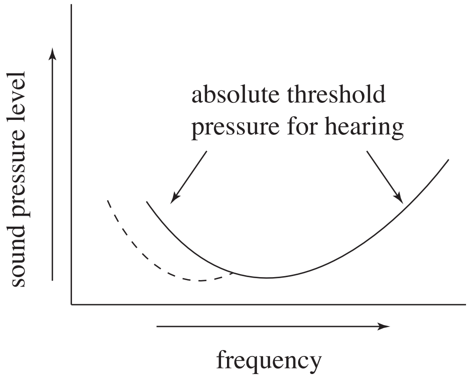
F.



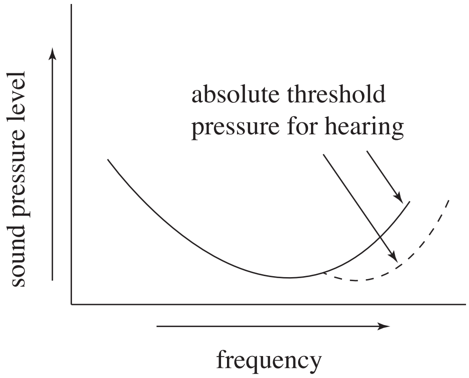
G.



H.



J.



39. A sound with a frequency of 3×10^3 cyc/sec causes pain at 115 db. Which of the following actions would eliminate the pain?

I. Reducing the frequency to 10^3 cyc/sec
II. Increasing the frequency to 10^4 cyc/sec
III. Reducing the sound pressure level by 5 db

A. II only
B. I and III only
C. III only
D. I, II, and III

40. Based on Figure 1, does *P* depend on the frequency of sound at a given sound pressure level?

F. No, because as frequency increases, *P* increases.
G. No, because as frequency increases, *P* remains constant.
H. Yes, because as frequency increases, *P* increases.
J. Yes, because as frequency increases, *P* remains constant.