

## Periodic Table of the Elements

1 <b>H</b> 1.0																	2 <b>He</b> 4.0
3 <b>Li</b> 6.9	4 <b>Be</b> 9.0											5 <b>B</b> 10.8	6 <b>C</b> 12.0	7 <b>N</b> 14.0	8 <b>O</b> 16.0	9 <b>F</b> 19.0	10 <b>Ne</b> 20.2
11 <b>Na</b> 23.0	12 <b>Mg</b> 24.3											13 <b>Al</b> 27.0	14 <b>Si</b> 28.1	15 <b>P</b> 31.0	16 <b>S</b> 32.1	17 <b>Cl</b> 35.5	18 <b>Ar</b> 39.9
19 <b>K</b> 39.1	20 <b>Ca</b> 40.1	21 <b>Sc</b> 45.0	22 <b>Ti</b> 47.9	23 <b>V</b> 50.9	24 <b>Cr</b> 52.0	25 <b>Mn</b> 54.9	26 <b>Fe</b> 55.8	27 <b>Co</b> 58.9	28 <b>Ni</b> 58.7	29 <b>Cu</b> 63.5	30 <b>Zn</b> 65.4	31 <b>Ga</b> 69.7	32 <b>Ge</b> 72.6	33 <b>As</b> 74.9	34 <b>Se</b> 79.0	35 <b>Br</b> 79.9	36 <b>Kr</b> 83.8
37 <b>Rb</b> 85.5	38 <b>Sr</b> 87.6	39 <b>Y</b> 88.9	40 <b>Zr</b> 91.2	41 <b>Nb</b> 92.9	42 <b>Mo</b> 95.9	43 <b>Tc</b> (98)	44 <b>Ru</b> 101.1	45 <b>Rh</b> 102.9	46 <b>Pd</b> 106.4	47 <b>Ag</b> 107.9	48 <b>Cd</b> 112.4	49 <b>In</b> 114.8	50 <b>Sn</b> 118.7	51 <b>Sb</b> 121.8	52 <b>Te</b> 127.6	53 <b>I</b> 126.9	54 <b>Xe</b> 131.3
55 <b>Cs</b> 132.9	56 <b>Ba</b> 137.3	57 <b>La*</b> 138.9	72 <b>Hf</b> 178.5	73 <b>Ta</b> 180.9	74 <b>W</b> 183.9	75 <b>Re</b> 186.2	76 <b>Os</b> 190.2	77 <b>Ir</b> 192.2	78 <b>Pt</b> 195.1	79 <b>Au</b> 197.0	80 <b>Hg</b> 200.6	81 <b>Tl</b> 204.4	82 <b>Pb</b> 207.2	83 <b>Bi</b> 209.0	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)
87 <b>Fr</b> (223)	88 <b>Ra</b> (226)	89 <b>Ac†</b> (227)	104 <b>Unq†</b> (261)	105 <b>Unp</b> (262)	106 <b>Unh</b> (263)	107 <b>Uns</b> (262)	108 <b>Uno</b> (265)	109 <b>Une</b> (267)									
			*	58 <b>Ce</b> 140.1	59 <b>Pr</b> 140.9	60 <b>Nd</b> 144.2	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.4	63 <b>Eu</b> 152.0	64 <b>Gd</b> 157.3	65 <b>Tb</b> 158.9	66 <b>Dy</b> 162.5	67 <b>Ho</b> 164.9	68 <b>Er</b> 167.3	69 <b>Tm</b> 168.9	70 <b>Yb</b> 173.0	71 <b>Lu</b> 175.0
			†	90 <b>Th</b> 232.0	91 <b>Pa</b> (231)	92 <b>U</b> 238.0	93 <b>Np</b> (237)	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (260)

## **Physical Sciences**

Time: 100 minutes

Questions: 1-77

Most questions in the Physical Sciences test are organized into groups, each containing a descriptive passage. After studying the passage, select the one best answer to each question in the group. Some questions are not based on a descriptive passage and are also independent of each other. If you are not certain of an answer, eliminate the alternatives that you know to be incorrect and then select an answer from the remaining alternatives. Indicate your selected answer by marking the corresponding answer on your answer sheet. A periodic table is provided for your use. You may consult it whenever you wish.

---

This document has been encoded to link this download to your member account. The AAMC and its Section for the MCAT hold the copyrights to the content of this Practice Test. Therefore, there can be no sharing or reproduction of materials from the Practice Test in any form (electronic, voice, or other means). If there are any questions about the use of the material in the Practice Test, please contact the MCAT Information Line (202-828-0690).

## Passage I

Chemical bonds are commonly classified as ionic or covalent. Virtually all compounds that are characterized as ionic are solids at room temperature. Some covalent compounds are solids, but many are liquids or gases. The vast majority of covalent compounds are comprised exclusively of nonmetallic elements, whereas binary ionic compounds are made up of a metal and a nonmetal. The aqueous solutions of ionic compounds conduct electricity, whereas those of covalent compounds do not. The ionization energies, electron affinities and electronegativities of bonded atoms provide information about the nature of a chemical bond. Table 1 shows the electronegativities of certain main-group elements.

**Table 1** Electronegativities of Selected Elements

I	II	III	IV	V	VI	VII
Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2	Al 1.5	Si 2.8	P 2.1	S 2.5	Cl 3.0
K 0.8	Ca 1.0	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8
Rb 0.8	Sr 1.0	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5

1. With respect to bonding and electrical conductivity, respectively, sulfur hexafluoride,  $\text{SF}_6(g)$ , would be described as:  
A) covalent and a nonconductor.  
B) ionic and a nonconductor.  
C) covalent and a conductor.  
D) ionic and a conductor.
2. Where are nonmetals found in the periodic table?  
A) Right side  
B) Left side  
C) Top half  
D) Bottom half

3. Which of the following pairs of compounds provides an example of ionic and covalent bonding, respectively?  
A)  $\text{HBr}(g)$  and  $\text{NaCl}(s)$   
B)  $\text{NaCl}(s)$  and  $\text{NaI}(s)$   
C)  $\text{NaI}(s)$  and  $\text{NaCl}(s)$   
D)  $\text{NaCl}(s)$  and  $\text{HBr}(g)$
4. Which of the following compounds has the most ionic character?  
A)  $\text{KBr}(s)$   
B)  $\text{CsCl}(s)$   
C)  $\text{NaI}(s)$   
D)  $\text{RbBr}(s)$
5. Which of the following statements is consistent with the incorrect conclusion that  $\text{HCl}$  is an ionic compound?  
A) It is a gas at room temperature.  
B) A 1 M solution freezes below  $0^\circ\text{C}$ .  
C) A 1 M solution conducts electricity.  
D) It is composed of two nonmetals.

## Passage II

*Magnetic resonance imaging* (MRI) provides a less invasive alternative to X rays as a diagnostic tool.

Contrast (differences in brightness between different locations) in X-ray images, usually a few percent, results from differences in the attenuation (absorption and scattering) of X rays in tissue. Attenuation coefficients are roughly proportional to the atomic numbers of elements contained in the tissue. To enhance contrasts in images, dyes often must be injected into the tissue being examined.

MRI uses magnetic fields to produce high-contrast images of human tissue. Human tissue contains H atoms; each H atom has a nonzero *nuclear magnetic dipole moment*,  $\mu$ . (Note: Atomic nuclei with a net spin of zero have  $\mu = 0$ .) In MRI, the nucleus of a hydrogen atom is affected by 3 magnetic fields:  $B_1$ ,  $B_2$ , and  $B_3$ .  $B_1$  and  $B_2$  are fields produced by the MRI device that are always perpendicular to each other;  $B_1$  is static and  $B_2$  rotates.  $B_3$  is the vector sum of the magnetic fields of electrons and other nuclei in the vicinity of the H atom.

If  $\mu$  is parallel to  $B_1$  when  $B_2$  begins rotating, the H nucleus will precess at an angular frequency  $\omega_d$  around the direction of  $B_1$ . (Note:  $\omega_d = 4\pi\mu B_1/h$ , where  $h$  is Planck's constant.) If the rotational frequency of  $B_2$  equals  $\omega_d$  (a condition called *resonance*), the nucleus can become *antiparallel to* (make a  $180^\circ$  angle with)  $B_1$ . In MRI applications, resonance occurs at radio frequencies.

If  $\mu$  is antiparallel to  $B_1$ , the H nucleus eventually will *relax* (become parallel to the field) and emit energy that is used to produce an image. A hydrogen atom's chemical environment largely determines the relaxation time. In human tissue, adjacent locations with different chemical compositions can produce images with contrasts of several hundred percent.

6. According to the passage, the magnitude of  $B_3$  at the position of a given hydrogen nucleus is determined by the:
  - A) chemical environment of the nucleus.
  - B) mass of the nucleus.
  - C) radius of the nucleus.
  - D) charge of the nucleus.
7. Consider an H nucleus with  $\mu$  pointing in a direction  $180^\circ$  from a magnetic field. When the nucleus relaxes, which of the following most likely will result?
  - A) The magnitude of  $\mu$  will decrease to zero.
  - B) The magnitude of the magnetic field will decrease to zero.
  - C) The nucleus will emit a photon.
  - D) The nucleus will absorb a photon.
8. X-ray imaging sometimes requires the use of contrast dyes. In MRI, dyes are:
  - A) less toxic.
  - B) not needed.
  - C) needed but not always used.
  - D) always used.

9. Human proteins are composed mostly of the elements C, H, O, N, and S. Without dyes, X-ray images of tissue containing different proteins do NOT have high contrasts, most likely because:

- A) dyes do not bind well to proteins.
- B) protein bonds are broken by the radiation, resulting in the formation of free radicals.
- C) the differences in the atomic numbers of the elements are not large enough.
- D) proteins are opaque to X rays.

10. For a given magnitude of  $B_1$ , the nucleus with the nonzero precession frequency will be which of the following?

- A)  ${}^4_2\text{He}$
- B)  ${}^{16}_8\text{O}$
- C)  ${}^{19}_9\text{F}$
- D)  ${}^{208}_{82}\text{Pb}$

11. To adjust  $\omega_d$  of H nuclei, a diagnostician is most likely to vary which of the following?

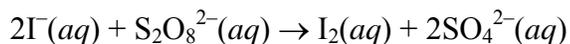
- A)  $B_1$
- B)  $B_3$
- C)  $h$
- D)  $\mu$

12. According to the passage, at resonance,  $B_2$  rotates an H nucleus through an angle of:

- A)  $45^\circ$ .
  - B)  $90^\circ$ .
  - C)  $180^\circ$ .
  - D)  $270^\circ$ .
-

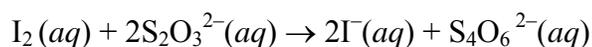
### Passage III

A group of students measured the relative rate of Reaction 1 under various conditions.



#### Reaction 1 (slow step)

The students measured the amount of time that passed until a fraction ( $X$  moles) of the  $\text{I}^-(aq)$  was converted into  $\text{I}_2(aq)$  by adding the corresponding amount of  $\text{Na}_2\text{S}_2\text{O}_3(aq)$  to react with the  $\text{I}_2(aq)$ , as shown in Reaction 2.



#### Reaction 2 (fast step)

They used starch as an indicator to detect the excess  $\text{I}_2(aq)$  that accumulated when the  $\text{S}_2\text{O}_3^{2-}(aq)$  was used up. The solution turned dark blue when starch and  $\text{I}_2(aq)$  combined.

The students prepared two solutions.

- Solution A contained  $\text{KI}(aq)$  and  $\text{Na}_2\text{S}_2\text{O}_3(aq)$ .
- Solution B contained  $(\text{NH}_4)_2\text{S}_2\text{O}_8(aq)$  and starch.

They combined Solutions A and B and measured the length of time for the combined solution to turn dark blue. They varied the volumes of Solution A, Solution B, and  $\text{H}_2\text{O}$  (Tubes 1, 2, and 3) and the temperature (Tubes 4 and 5). The students added 1 drop of 0.1 M  $\text{CuSO}_4(aq)$  to Tube 6. The results are summarized in Table 1.

**Table 1** The Effect of Various Conditions on the Rate of Reaction 1

Tube	Volume (mL)			Temperature (°C)	Time (sec)
	Solution A	Solution B	H <sub>2</sub> O		
1	20	20	0	22	29
2	20	10	10	22	71
3	10	20	10	22	72
4	20	20	0	12	58
5	20	20	0	32	18
6*	20	20	0	22	19

\* Note:  $\text{CuSO}_4$  was added to Tube 6.

13. The effect of temperature on the rate of the reaction can best be determined by comparing Tube 5 with which of the following tubes?

- A) Tube 2
- B) Tube 3
- C) Tube 4
- D) Tube 6

14. The results in Table 1 would most likely NOT be affected if the students had added *excess*:

- A)  $\text{KI}(aq)$  to Solution A.
- B)  $\text{Na}_2\text{S}_2\text{O}_3(aq)$  to Solution A.
- C)  $(\text{NH}_4)_2\text{S}_2\text{O}_8(aq)$  to Solution B.
- D) starch to Solution B.

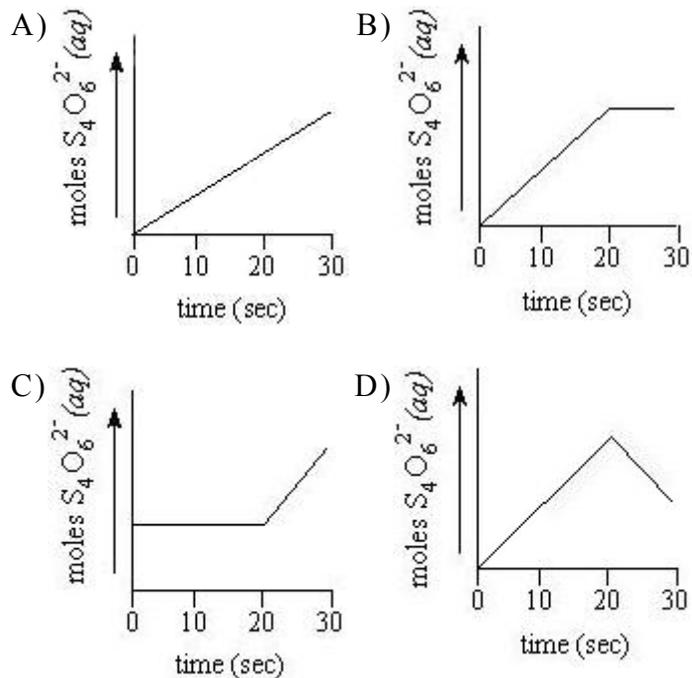
15. In Tube 6, what is the most likely function of  $\text{CuSO}_4(aq)$ ?

- A) Reactant
- B) Indicator
- C) Inhibitor
- D) Catalyst

16. The solution in Tube 1 turned dark blue more rapidly than did the solution in Tube 4, because the:

- A) rate of Reaction 2 was slower in Tube 1 than in Tube 4.
- B) average kinetic energies of  $\Gamma(aq)$  and  $S_2O_8^{2-}(aq)$  were greater in Tube 1 than in Tube 4.
- C) concentrations of  $\Gamma(aq)$  and  $S_2O_8^{2-}(aq)$  were greater in Tube 1 than in Tube 4.
- D) concentration of starch was greater in Tube 1 than in Tube 4.

17. Which of the following graphs best shows the number of moles of  $S_4O_6^{2-}(aq)$  in Tube 6 as time passes?



## Passage IV

Aristotle believed that the time it takes for an object to fall a given distance is inversely proportional to its weight. According to Aristotle's theory of *natural motion*, an object in motion is propelled at a constant velocity by the air which is pushed aside by the object, filling the space behind it. When an object is acted upon by a force outside the object, the object undergoes *violent motion*, according to Aristotle. Once the outside force abates, he believed, the object resumes natural motion. However, Aristotelian theories do not satisfactorily explain why an object moving upward through the air slows, stops, and falls to Earth.

To study free-falling objects, Galileo conducted experiments with spheres on a nearly frictionless inclined plane. Starting from rest, a sphere moved down the plane a distance  $d$  in a time  $t$ . Galileo found that the ratio of  $d$  to  $t^2$  was a constant. He also found that the value of the constant increased as the angle of inclination increased.

18. According to the results of Galileo's experiments described in the passage, the ratio of  $d$  to  $t^2$  attained its maximum value when:
- A) the inclined plane was horizontal.
  - B) the inclined plane was vertical.
  - C) natural motion began.
  - D) violent motion ceased.
19. As described in the passage, Aristotle's theories of motion do NOT deal with which of the following observations?
- A) An object in a vacuum can move with constant velocity.
  - B) An object in free fall can reach a constant velocity.
  - C) A mass on a spring undergoes violent motion.
  - D) A heavy body falls with a greater velocity than a light one.

20. When designing his experiment, Galileo could have allowed spheres to drop from a height of 10 m rather than using the 10-m inclined plane described in the passage. The main advantage to using the inclined plane is that on the inclined plane the:

- A) final velocity of a sphere is smaller.
- B) final velocity of a sphere is larger.
- C) spheres take longer to reach the bottom.
- D) spheres take less time to reach the bottom.

21. Spheres A, B, C, and D have identical radii and masses of 10 g, 40 g, 20 g, and 30 g, respectively. According to Aristotle's theory, if the spheres are dropped to the ground from the same height, which object will have the highest terminal velocity?

- A) Object A
- B) Object B
- C) Object C
- D) Object D

22. Object A has 2 times the density and  $\frac{1}{2}$  the volume of Object B. According to Aristotle's theory, if A and B are dropped to Earth from the same height, which object will reach Earth first? (Note: Ignore the effects of friction.)

- A) Object A, because it is denser than object B
  - B) Object A, because it is heavier than object B
  - C) Object B, because it is heavier than object A
  - D) The objects will reach Earth at the same time.
-

**These questions are not based on a descriptive passage and are independent of each other.**

**23.** A sparingly soluble metal hydroxide,  $M(OH)_2$  has a molar solubility of  $S$  mol/L at  $25^\circ\text{C}$ . Its  $K_{sp}$  value is:

- A)  $S^2$ .
- B)  $2S^2$ .
- C)  $2S^3$ .
- D)  $4S^3$ .

**24.** If the quantity of gas remains unchanged while its temperature increases, the volume of the gas will:

- A) always increase, because volume is directly proportional to temperature.
- B) always decrease, because volume is inversely proportional to temperature.
- C) increase if pressure remains constant.
- D) decrease if pressure remains constant.

**25.** An astronaut on Earth notes that in her soft drink an ice cube floats with  $9/10$  of its volume submerged. If she were instead in a lunar module parked on the Moon where the gravitation force is  $1/6$  that of Earth, the ice in the same soft drink would float:

- A) with more than  $9/10$  submerged.
- B) with  $9/10$  submerged.
- C) with  $6/10$  submerged.
- D) totally submerged.

**26.** A glass fiber carries a light digital signal long distances with a minimum loss of amplitude. What optical property of glass allows this phenomenon?

- A) Dispersion
- B) Refraction
- C) Reflection
- D) Diffraction

## Passage V

The hardness of water is caused by the presence of calcium and other ions that form insoluble compounds with ordinary soap. Ground water in limestone regions may contain a large amount of calcium as  $\text{CaCO}_3$ . The high degree of solubility of  $\text{CaCO}_3$  in acidic solutions (due to conversion to soluble  $\text{Ca}(\text{HCO}_3)_2$ ) is responsible for water hardness in these regions.

One way to soften acidic groundwater is by simply boiling, which results in the removal of calcium ion by Reaction 1.



### Reaction 1

The precipitated calcium carbonate is then removed by filtration.

An alternative method of achieving the same result is to add calcium hydroxide to the water sample, which allows removal of calcium carbonate by Reaction 2.



### Reaction 2

This method is a more economical means of reducing the water hardness on a large scale because of the large fuel cost of boiling.

27. Reaction 1 is an effective means of decreasing the hardness of an acidic water sample because it:

- A) increases the pH and decreases the solubility of  $\text{CaCO}_3$ .
- B) decreases the pH and decreases the solubility of  $\text{CaCO}_3$ .
- C) increases the pH and converts  $\text{HCO}_3^-$  to water.
- D) decreases the pH and removes  $\text{Ca}^{2+}$  from solution.

28. What is the effect of a high level of atmospheric  $\text{CO}_2$  on the hardness of water in limestone regions?

- A) It would lower the pH and increase the solubility of  $\text{CaCO}_3$ .
- B) It would raise the pH and increase the solubility of  $\text{CaCO}_3$ .
- C) It would lower the pH and decrease the solubility of  $\text{CaCO}_3$ .
- D) It would raise the pH and decrease the solubility of  $\text{CaCO}_3$ .

29. How many grams of  $\text{CaCO}_3$  would be formed in Reaction 1 if the  $\text{CO}_2$  evolved occupies 11.2 L at STP?

- A) 0.5 g
- B) 11.2 g
- C) 50 g
- D) 100 g

30. If the pH of the water sample were high such that all the carbonate is present as  $\text{CO}_3^{2-}$ , what would be the concentration of  $\text{Ca}^{2+}$ ? (The  $K_{sp}$  of  $\text{CaCO}_3$  is  $4.8 \times 10^{-9}$ .)

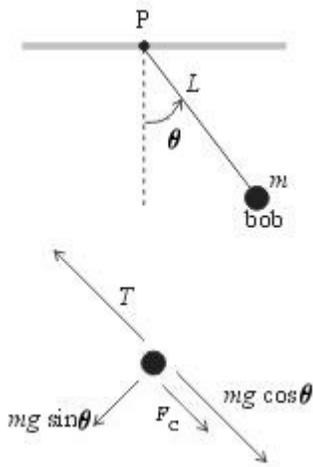
- A)  $(4.8 \times 10^{-9})^2 \text{ M}$
- B)  $(4.8 \times 10^{-9})^{1/2} \text{ M}$
- C)  $4.8 \times 10^{-9} \text{ M}$
- D)  $(4.8 \times 10^{-9})^{1/3} \text{ M}$

31. The addition of excess  $\text{Ca}^{2+}$  to a solution containing  $\text{Ca}^{2+}$  and  $\text{CO}_3^{2-}$  ions causes  $\text{CaCO}_3$  to precipitate because:

- A)  $K_{sp}$  for  $\text{CaCO}_3$  would increase due to the increase in  $[\text{Ca}^{2+}]$ .
- B)  $K_{sp}$  for  $\text{CaCO}_3$  would decrease due to the increase in  $[\text{Ca}^{2+}]$ .
- C)  $[\text{CO}_3^{2-}]$  would increase to maintain  $K_{sp}$ .
- D)  $[\text{CO}_3^{2-}]$  would decrease to maintain  $K_{sp}$ .

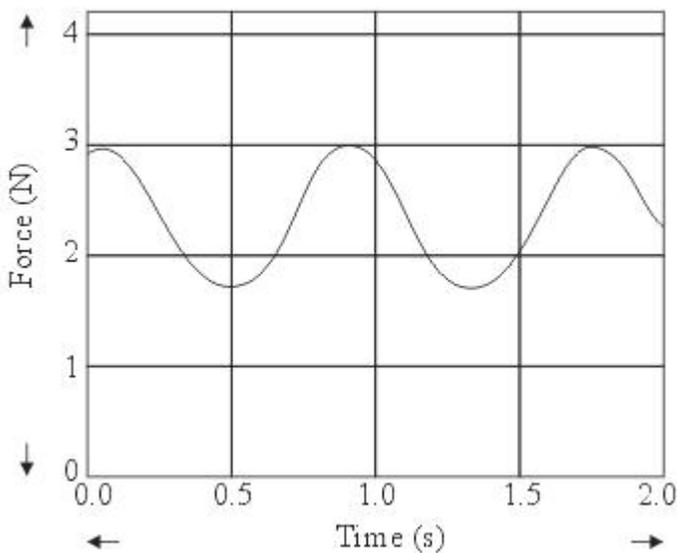
## Passage VI

Students in a physics class measure the tension  $T$  in a pendulum string, Figure 1.



**Figure 1** Pendulum variables and forces

The tension arises from two sources: the component of the weight of the bob  $mg$  in the direction of the string and the centrifugal force  $F_c$ , which is the reaction force to the centripetal force on the bob causing it to move along a circular arc of radius  $L$ . A force sensor at the pivot point  $P$  gives a voltage output proportional to the tension as a function of time, Figure 2.



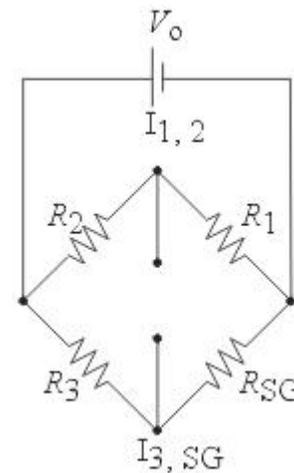
**Figure 2** Time dependence of the string tension of a swinging pendulum

In the small angle approximation ( $\sin \theta \approx \theta$ ) the tension in units of the weight of the bob is given by

$$T/mg = \theta_0^2 \cos^2 \omega t + \cos(\theta_0 \sin \omega t)$$

where  $\theta_0$  is the amplitude of the swing and  $\omega$  is the angular frequency, in rad/s, of the pendulum. Use  $g = 10 \text{ m/s}^2$  when needed.

A strain gauge is used as the force sensor at point  $P$ . This device is based on the fact that the resistance of metals and semiconductors varies with the external pressure or force exerted on them. A change in the resistance of a strain gauge can be measured accurately by using a Wheatstone bridge, Figure 3, in which the voltage  $V$  changes when  $R_{SG}$  changes.



**Figure 3** Wheatstone bridge

32. What is the expression for the angular frequency  $\omega$  of a pendulum?

- A)  $2\pi mg/L$
- B)  $(L/g)^{1/2}$
- C)  $2\pi(g/L)^{1/2}$
- D)  $(g/L)^{1/2}$

33. The equation for tension used in the passage requires  $\theta_0$  to be units of radians. How is an angle of  $30^\circ$  converted to radians?

- A)  $\theta_0 = 30^\circ \times \pi$
- B)  $\theta_0 = 30^\circ \times 2\pi$
- C)  $\theta_0 = 30^\circ \times \pi/180^\circ$
- D)  $\theta_0 = 30^\circ \times \pi/360^\circ$

34. If all the resistors in Figure 3 are  $200 \Omega$ , what is the current from the battery when  $V_0 = 12 \text{ V}$ ?

- A) 30 mA
- B) 60 mA
- C) 120 mA
- D) 240 mA

35. What is the magnitude of the restoring force on the pendulum bob at angle  $\theta$ ?

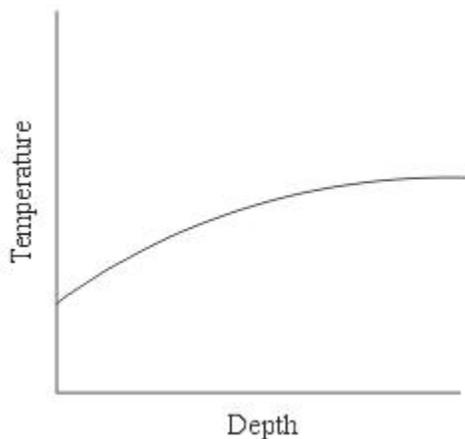
- A)  $mg$
- B)  $mg\sin\theta$
- C)  $mg\cos\theta$
- D)  $mg\tan\theta$

36. What mechanism supplies the tension in the string at the molecular level?

- A) Magnetic forces
- B) Electron transfer
- C) Gravitational forces
- D) Stretching bond lengths

## Passage VII

A large cylindrical concrete tank filled with water is used to study the effects of pressure on gases. The tank is 10 m deep and has an inside diameter of 5 m. The temperature of the water is kept uniform throughout the tank by a series of thermostats and electrical heaters. A drain pipe projecting horizontally from the bottom of the tank side has a valve that can be opened to rapidly empty the tank. The pipe has length  $L$  and is tapered, with a cross section of  $0.2 \text{ m}^2$  next to the tank and  $0.1 \text{ m}^2$  at the other end. Air-filled rubber balloons, with small lead weights tied to them by pieces of string, are used in the experiments. Figure 1 shows the temperature of the air inside a balloon as a function of its depth when it is cut loose from the bottom of the tank and allowed to rise freely to the surface. (Note: The densities of water and lead are  $10^3 \text{ kg/m}^3$  and  $1.13 \times 10^4 \text{ kg/m}^3$ , respectively, and the acceleration due to gravity is  $10 \text{ m/s}^2$ .)



**Figure 1** Air temperature inside balloon as a function of its depth in the tank

37. Each lead weight has a volume of  $4 \times 10^{-6} \text{ m}^3$ . What buoyancy force does the water exert on a lead weight?
- A)  $4.0 \times 10^{-2} \text{ N}$
  - B)  $4.5 \times 10^{-2} \text{ N}$
  - C)  $4.1 \times 10^{-1} \text{ N}$
  - D)  $4.5 \times 10^{-1} \text{ N}$
38. Which of the following items of information would NOT help in predicting the results shown in Figure 1?
- A) The number of air molecules inside the balloon
  - B) The thermal conductivity of the rubber
  - C) The variation with depth in the speed of the balloon
  - D) The total mass of the water in the tank
39. Which of the following statements best explains the temperature change shown in Figure 1?
- A) The work done on the gas by the water pressure decreases its temperature.
  - B) The work done by the gas in expanding decreases its internal energy.
  - C) The balloon and water exchange heat, increasing the temperature of the gas.
  - D) The compression of the gas decreases its temperature.

**40.** Air-filled, thin-walled steel spheres were suggested for experiments in the tank instead of rubber balloons. The most likely reason that this idea was rejected is that steel spheres would:

- A) not be sufficiently flexible.
- B) be too heavy.
- C) not be airtight.
- D) rust too quickly.

**41.** What vertical forces are acting on a balloon as it ascends?

- A) Weight only
- B) Buoyancy force only
- C) Weight and buoyancy force only
- D) Water pressure and buoyancy force only

**42.** If the valve is opened to drain the tank, where is the speed of the flowing water the greatest?

- A) At the top of the tank
- B) At the bottom of the tank
- C) At the wide end of the pipe
- D) At the narrow end of the pipe

**43.** A balloon is attached to a weight that keeps it from ascending quickly enough for the air in the balloon to change temperature. When the volume of the balloon has doubled, how has the pressure of the air inside changed?

- A) It has been reduced to one-quarter the original pressure.
  - B) It has been reduced to one-half the original pressure.
  - C) It has remained at the original pressure.
  - D) It has been increased to twice the original pressure.
-

## Passage VIII

The following experiments study the reactivities of several active metals (Experiment 1) and halogens (Experiment 2).

### Experiment 1

Pea-sized samples of five active metals were placed in deionized water, and observations were recorded in Table 1.

**Table 1** Observations

Metal used	Observation upon adding the metal to water	Observation of the resulting solution
Mg	No obvious reaction	Neutral
Ca	Sank, and slowly gave off bubbles of a gas	Basic
Li	Moved over the surface slowly fizzing	Basic
Na	Moved over the surface vigorously fizzing, caught fire	Basic
K	Moved over the surface vigorously fizzing, exploded loudly	Basic

### Experiment 2

A saturated aqueous solution of  $\text{Cl}_2$  was added to separate aqueous solutions of NaF, NaCl, NaBr, and NaI and mixed well. Observations were recorded. In addition, samples of salt solutions were added to separate electrolysis cells, and the minimum voltage required to produce an observable reaction at the anode was recorded.  $\text{H}_2(g)$  was produced at the cathode in each cell and, except for the NaF solution, the solutions became basic. Results are recorded in Table 2.

**Table 2** Results

Solution	Chlorine water	Electrolysis cell voltage and product
NaF	No change	2.06 V; $\text{O}_2(g)$
NaCl	No change	2.19 V; $\text{Cl}_2(g)$
NaBr	Red-brown	1.90 V; $\text{Br}_2(aq)$
NaI	Yellow-brown	1.37 V; $\text{I}_2(aq)$

44. The process taking place at the cathode was:

- A) oxidation by a loss of electrons.
- B) oxidation by a gain of electrons.
- C) reduction by a loss of electrons.
- D) reduction by a gain of electrons.

45. What is the electron configuration of the metal ion produced when Ca reacted with water in Experiment 1?

- A)  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
- B)  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
- C)  $1s^2 2s^2 2p^6 3s^2 3p^6$
- D)  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$

46. Which of the following properties is most useful in explaining the trend in the reactivities in Experiment 1?

- A) Electronegativity
- B) Ionization potential
- C) Electron affinity
- D) Polarizability

Experiment 1 was repeated with 0.40 g of

47. calcium, and the gas that evolved was collected.

The identity of the gas, and its approximate volume at 1.0 atm and 27°C were:

(Note:  $R = 0.0821 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$ )

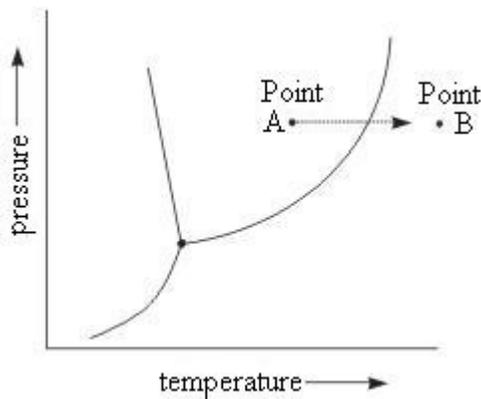
- A)  $\text{H}_2$ , 250 mL.
- B)  $\text{H}_2$ , 500 mL.
- C)  $\text{O}_2$ , 250 mL.
- D)  $\text{O}_2$ , 500 mL.

48. When alkali metals are held in a colorless flame, the metals vaporize and impart a brilliant color to the flame. Lithium imparts a bright red color, sodium a yellow color, and potassium a violet color. What is the origin of these colors?

- A) Excited electrons in the metals drop to lower energy levels and emit specific wavelengths of light.
  - B) Electrons in the metals are raised to higher energy levels by absorbing specific wavelengths of light.
  - C) Electrons in the metals are converted into gases in the flame that emit specific wavelengths of light.
  - D) Specific wavelengths of light are absorbed when the metal is converted from the solid phase to the gas phase in the flame.
-

These questions are not based on a descriptive passage and are independent of each other.

49. Consider the phase diagram of water below.



The arrow proceeding from Point A to Point B represents:

- A) melting.
  - B) sublimation.
  - C) condensation.
  - D) vaporization.
50. Which of the following statements best characterizes a material that is a good insulator but a poor conductor?
- A) The material contains no electrons.
  - B) The magnitude of the electric field inside the material is always equal to zero.
  - C) The atoms in the material can easily move from one lattice site to another.
  - D) Electrons in the material cannot easily move from one atom to another.

51. An object with a mass of 0.1 kg absorbs 250 J of heat while changing temperature from 20°C to 25°C. What is the specific heat of the object?

- A) 125 J/(kg•°C)
- B) 250 J/(kg•°C)
- C) 375 J/(kg•°C)
- D) 500 J/(kg•°C)

52. At a given temperature, the resistance of a wire to direct current depends only on the:

- A) voltage applied across the wire.
- B) resistivity, length, and cross-sectional area.
- C) inductance, length, and cross-sectional area.
- D) resistivity, length, and capacitance.

53. Which of the following electron configurations of nitrogen is the most stable?

- A)  $1s^2 2s^1 2p^4$
  - B)  $1s^2 2s^2 2p^3$
  - C)  $1s^1 2s^2 2p^4$
  - D)  $1s^2 2s^2 2p^2 3s^1$
-

## Passage IX

A class is given a demonstration of solution chemistry and solubility equilibria.

A 6.57-g sample of  $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$  (molar mass 262.84) is dissolved in enough water to make 50.00 mL of a green solution, and 7.15 g of  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$  (molar mass 286.14) is dissolved in enough water to make 50.00 mL of a colorless solution. The two solutions are mixed, and a green precipitate forms. The resulting slurry is divided into two equal portions. To one portion is added an excess of 6 M HCl, which results in the disappearance of the precipitate and a rapid evolution of a gas. To the second portion is added a few milliliters of 6 M  $\text{NH}_3$ . The precipitate dissolves, and a blue solution forms.

54. How many sodium ions are in the initial 50.00-mL solution of  $\text{Na}_2\text{CO}_3$ ?

- A)  $1.50 \times 10^{22}$
- B)  $3.00 \times 10^{22}$
- C)  $6.02 \times 10^{23}$
- D)  $12.0 \times 10^{23}$

55. If red litmus paper is dipped into the  $\text{Na}_2\text{CO}_3$  solution, it will:

- A) remain red, because carbonate is an acidic salt.
- B) remain red, because sodium carbonate is neutral.
- C) turn blue, because carbonate reacts with water to produce  $\text{OH}^-$ .
- D) turn blue, because sodium ions form sodium hydroxide in water.

56. What is the maximum number of moles of nickel carbonate ( $\text{NiCO}_3$ ) that can form during the precipitation reaction?

- A) 0.025 mol
- B) 0.25 mol
- C) 1.00 mol
- D) 2.25 mol

57. According to the information in the passage, the gas that evolves is:

- A) sulfur dioxide.
- B) sulfur trioxide.
- C) carbon dioxide.
- D) carbon monoxide.

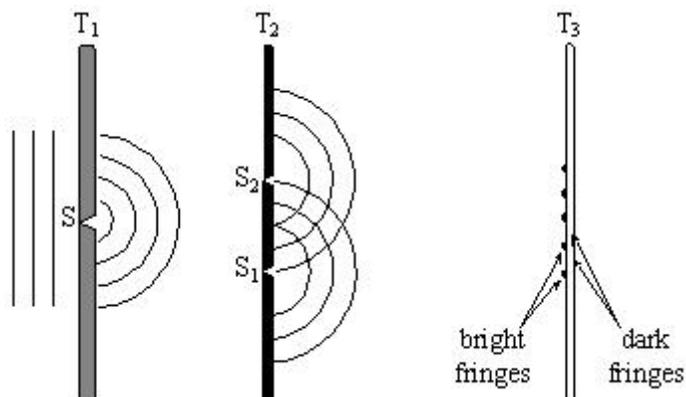
58. The ion responsible for the color of the solutions is:

- A) sulfate, because sulfur has *s* and *p* orbitals.
  - B) nickel(II), because it has a charge of +2.
  - C) nickel(II), because it has unfilled *d* orbitals.
  - D) sulfate, because it is a resonance-stabilized anion.
-

## Passage X

Light behaves like a wave in some experiments and a particle in others.

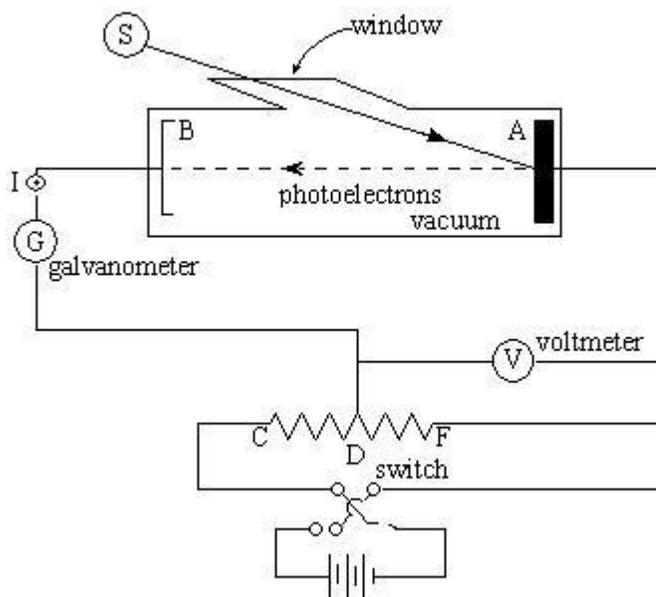
Young's experiment demonstrates the wave nature of light, as shown in the apparatus in Figure 1.



**Figure 1** Young's double-slit experiment

In Young's experiment, coherent light is produced by passing light through a narrow slit,  $S$ , in  $T_1$ . The coherent light is split into 2 closely spaced beams at slits  $S_1$  and  $S_2$  in  $T_2$ . The 2 beams then illuminate a distant target screen,  $T_3$ . The overlapped beams on the screen create a symmetrical pattern of alternating bright and dark lines called *interference fringes*. If light is wavelike, the brightest fringes occur where wave maxima overlap with other maxima or where minima overlap with other minima; the darkest fringes are produced by the overlap of maxima with minima. The *intensity* of a bright fringe depends on the amplitudes of the overlapped waves.

An experiment involving the photoelectric effect demonstrates that light behaves like a particle. Light particles are called *photons*; each photon has an energy,  $E$ . Source  $S$  in Figure 2 emits photons with varying values of  $E$ .



**Figure 2** Photoelectric experiment

The intensity of the source at energy  $E$  depends upon the number of photons emitted at  $E$  per second. The photons strike a metal plate,  $A$ . The *work function*,  $W$ , of the metal is similar to the ionization potential of an atom. When a photon's  $E$  exceeds  $W$ , the photon ejects an electron from the metal. The kinetic energy,  $K$ , of the ejected electron is the difference between  $E$  and  $W$ . The electrons are accelerated by an electric field and collected at Plate  $B$ .

To determine the maximum kinetic energy of electrons ejected from Plate  $A$ , the potential of Plate  $A$  is made more positive than that of Plate  $B$ . The smallest value of the potential difference that prevents the most energetic electrons from reaching Plate  $B$  is called the *stopping potential*,  $V_s$ .

59. Suppose a scientist tests Metals K, L, and M for use in Plate A of the photoelectric experiment. The work functions of K, L, and M are 5.0 eV, 8.0 eV, and 6.0 eV, respectively. If each metal is struck by a 7.0 eV photon, what will be the maximum kinetic energies (in eV) of the electrons ejected, if any, from K, L, and M, respectively?
- A) 2.0, 0.0, 1.0  
 B) 2.0, 1.0, 1.0  
 C) 2.0, 15.0, 0.0  
 D) 12.0, 15.0, 13.0
60. In the photoelectric experiment, which of the following changes will produce the largest increase in the value for  $I$ ?
- A) Plate A is replaced with one having a higher work function.  
 B) The electrical potential of Plate B is made more positive relative to that of Plate A.  
 C) The flux of photons having energies less than  $W$  is increased.  
 D) The average frequency of the photons is decreased.
61. In Young's experiment, if wavelength is increased, the bright fringes will become:
- A) brighter.  
 B) bluer.  
 C) closer together.  
 D) farther apart.
62. If light is wavelike and if diffractive effects are ignored, the fringes on  $T_3$  in Figure 1 should disappear when:
- A)  $\lambda$  is increased slightly.  
 B) light intensity is increased.  
 C)  $S_1$  is covered.  
 D)  $T_3$  is moved farther from  $T_2$ .
63. In Young's experiment, S produces spherical wave fronts. The light entering  $S_1$  and  $S_2$  will most likely consist of plane waves if the distance between:
- A)  $T_1$  and  $T_2$  is large.  
 B)  $T_1$  and  $T_2$  is small.  
 C)  $S_1$  and  $S_2$  is large.  
 D)  $T_2$  and  $T_3$  is small.
64. When Waves A, B, and C meet at the same point on the target screen, Wave A is  $180^\circ$  out of phase with Wave B and  $0^\circ$  out of phase with Wave C. If each of the 3 waves has an amplitude  $E$  when it reaches this point, the resulting wave amplitude at the point will be:
- A) zero.  
 B)  $E$ .  
 C)  $2E$ .  
 D)  $3E$ .
65. The wave theory states that for an electron to be ejected from a metal, light of sufficient intensity must be used. Based on the passage, does the particle theory agree with this aspect of the wave theory?
- A) Yes, because light intensity determines the work function of a metal  
 B) Yes, because light intensity depends only on frequency  
 C) No, because light waves cannot carry sufficient energy to eject an electron  
 D) No, because an electron can be ejected by a single high-energy photon

## Passage XI

Table 1 shows the results of mixing aqueous solutions of the various cations with aqueous solutions of the various anions. The solutions containing  $\text{CrO}_4^{2-}$  or  $\text{Fe}^{3+}$  were yellow before mixing, and the solution containing  $\text{Cu}^{2+}$  was blue before mixing.

**Table 1** Results of Mixing Aqueous Solutions of Cations and Anions

	$\text{Ag}^+$	$\text{Ca}^{2+}$	$\text{Cu}^{2+}$	$\text{Fe}^{3+}$
$\text{F}^-$	*	white ppt	*	*
$\text{Cl}^-$	white ppt	*	*	*
$\text{CrO}_4^{2-}$	red ppt	*	brown ppt	brown ppt
$\text{S}^{2-}$	black ppt	*	black ppt	brown ppt

\* = no reaction  
ppt = precipitate

Aqueous Solutions A, B, and C each contained a different ionic compound. The three ionic compounds were completely soluble in water. The cation in Solutions A, B, and C was either  $\text{Ag}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Cu}^{2+}$ , or  $\text{Fe}^{3+}$ . The anion in Solutions A, B, and C was either  $\text{F}^-$ ,  $\text{Cl}^-$ ,  $\text{CrO}_4^{2-}$ , or  $\text{S}^{2-}$ . Solution A was colorless, Solution B was yellow, and Solution C was blue. It was determined that Solution B contained  $\text{CaCrO}_4$  and that Solution C contained  $\text{CuCl}_2$ .

Mixing equal volumes of Solutions A, B, or C resulted in the formation of precipitates, as shown in Table 2.

**Table 2** Results of Mixing Solutions A, B, and C

Solutions mixed	Result
A + B	red ppt
A + C	white ppt
B + C	brown ppt

ppt = precipitate

66. If Solution A contains  $\text{Ag}^+$ , the anion component must be:

- A)  $\text{CrO}_4^{2-}$ .
- B)  $\text{Cl}^-$ .
- C)  $\text{F}^-$ .
- D)  $\text{S}^{2-}$ .

67. When aqueous solutions of the various anions and cations were mixed, precipitates formed because:

- A) few aqueous solutions can contain more than one cation or anion.
- B) the anions precipitated as solid metals.
- C) the solubilities of cations were decreased by the other cations.
- D) the solubility product of a compound was exceeded.

68. All of the precipitation reactions in Table 1 can be classified as:

- A) metathesis reactions.
- B) decomposition reactions.
- C) hydrolysis reactions.
- D) oxidation reactions.

69. In Table 1, which cation allowed for the greatest number of soluble compounds?

- A)  $\text{Ag}^+$
- B)  $\text{Ca}^{2+}$
- C)  $\text{Cu}^{2+}$
- D)  $\text{Fe}^{3+}$

70.  $\text{Ba}^{2+}(\text{aq})$  is an ion that is very toxic to mammals when taken internally. Which of the following compounds, mixed in water, would be the safest if accidentally swallowed?

- A)  $\text{BaSO}_4, K_{\text{sp}} = 1.1 \times 10^{-10}$
- B)  $\text{BaCO}_3, K_{\text{sp}} = 8.1 \times 10^{-9}$
- C)  $\text{BaSO}_3, K_{\text{sp}} = 8.0 \times 10^{-7}$
- D)  $\text{BaF}_2, K_{\text{sp}} = 1.7 \times 10^{-6}$

71. Which one of the following cations or anions would be useful in differentiating between a solution containing  $\text{FeCl}_3$  and one containing  $\text{FeF}_3$ ?

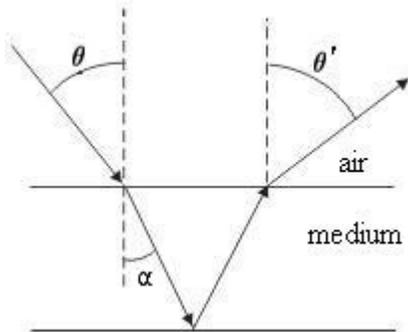
- A)  $\text{CrO}_4^{2-}$
  - B)  $\text{Ca}^{2+}$
  - C)  $\text{S}^{2-}$
  - D)  $\text{Cu}^{2+}$
-

**These questions are not based on a descriptive passage and are independent of each other.**

72. A battery in a circuit has an electromotive force given by  $E$  and an internal resistance of  $r$ . The battery provides a current  $i$  to the circuit. What is the terminal voltage of the battery?

- A)  $E$
- B)  $E - ir$
- C)  $E + ir$
- D)  $E + i^2r$

73.



A beam of light shines into a transparent medium with parallel surfaces. Part of the beam is reflected back into the air as diagrammed above. (The figure is NOT to scale.) The index of refraction of the medium is 1.5. Which of the following is true?

- A)  $\theta < \theta'$  and  $\theta < \alpha$
- B)  $\theta = \theta'$  and  $\theta > \alpha$
- C)  $\theta = \theta'$  and  $\theta < \alpha$
- D)  $\theta > \theta'$  and  $\theta > \alpha$

74. Although only molecules having much greater than the average kinetic energy can escape from a liquid, the temperature of a liquid in equilibrium with its vapor is found to be the same as that of the vapor. How can this be interpreted?

- A) The excess kinetic energy is transferred to air molecules.
- B) The excess kinetic energy is lost in collisions with the walls of the container.
- C) The higher kinetic energy of the vapor molecules is compensated for by their lower potential energy.
- D) The excess kinetic energy is expended on overcoming attractive forces exerted by the molecules of the liquid.

75. Sound of a known frequency, wavelength, intensity, and speed travels through air and bounces off an imperfect reflector which is moving toward the source. Which of the following properties of the sound remains the same before and after reflection?

- A) Speed
- B) Intensity
- C) Frequency
- D) Wavelength

76. In order to determine the relative speed of approach of a sound source by Doppler measurements, three of the following items of data are necessary. Which one is NOT required?

- A) The speed of sound in the medium
- B) The frequency of the emitted sound
- C) The frequency of the observed sound
- D) The distance between source and observer

77. Which of the following is equal to a change in momentum of an object?

- A) Force
- B) Acceleration
- C) Velocity
- D) Impulse

## **Verbal Reasoning**

Time: 85 minutes

Questions: 78-137

There are nine passages in the complete Verbal Reasoning test. Each passage is followed by several questions. After reading a passage, select the one best answer to each question. If you are not certain of an answer, eliminate the alternatives that you know to be incorrect and then select an answer from the remaining alternatives. Indicate your selected answer by marking the corresponding answer on your answer sheet.

---

This document has been encoded to link this download to your member account. The AAMC and its Section for the MCAT hold the copyrights to the content of this Practice Test. Therefore, there can be no sharing or reproduction of materials from the Practice Test in any form (electronic, voice, or other means). If there are any questions about the use of the material in the Practice Test, please contact the MCAT Information Line (202-828-0690).

## Passage I

There are two ways by which the spirit of a culture may be shriveled. In the first—the Orwellian—culture becomes a prison. In the second—the Huxleyan—culture becomes a burlesque. No one needs to be reminded that our world [has been] marred by many prison cultures whose structure Orwell described accurately in his parables. If one were to read both *1984* and *Animal Farm* . . . one would have a fairly precise blueprint of the machinery of thought control as it [recently operated] in scores of countries and on millions of people. . . .

What Huxley teaches [in his novel *Brave New World*] is that in the age of advanced technology, spiritual devastation is more likely to come from an enemy with a smiling face than from one whose countenance exudes suspicion and hate. In the Huxleyan prophecy, Big Brother does not watch us, by his choice. We watch him, by ours. . . . When, in short, a people become an audience and their public business a vaudeville act, then a nation finds itself at risk; culture death is a clear possibility.

In [the United States], Orwell's prophecies are of small relevance, but Huxley's are well under way toward being realized. For [the U.S.] is engaged in the world's most ambitious experiment to accommodate itself to the technological distractions made possible by the electric plug. This is an experiment that . . . [has] reached a perverse maturity in America's consuming love affair with television. . . . By ushering in the Age of Television, America has given the world the clearest available glimpse of the Huxleyan future.

Those who speak about this matter must often raise their voices to a near-hysterical pitch, inviting the charge that they are everything from wimps to public nuisances to Jeremiahs. But they do so because what they want others to see appears benign, when it is not invisible altogether. An Orwellian world is much easier to recognize, and to oppose, than a Huxleyan. Everything in our background has prepared us to know and resist a prison when the gates begin to close around us. . . . [But] to whom do we complain, and when, and in what tone of voice, when serious discourse dissolves into giggles? What is the antidote

to a culture's being drained by laughter?

. . . What is happening in America is not the design of an articulated ideology. . . . But it is an ideology nonetheless, for it imposes a way of life, a set of relations among people and ideas, about which there has been no consensus, no discussion, and no opposition—only compliance. Public consciousness has not yet assimilated the point that technology is ideology. . . .

To be unaware that a technology comes equipped with a program for social change, to maintain that technology is neutral, to make the assumption that technology is always a friend to culture is, at this late hour, stupidity plain and simple. . . . Introduce the alphabet to a culture and you change its cognitive habits, its social relations, its notions of community, history, and religion. Introduce the printing press with movable type and you do the same. Introduce speed-of-light transmission of images and you make a cultural revolution. Without a vote; without polemics; without guerilla resistance—here is ideology, pure if not serene. Here is ideology without words, and all the more powerful for their absence. All that is required to make it stick is a population that devoutly believes in the inevitability of progress. . . .

[Huxley] believed . . . that we are in a race between education and disaster, and he wrote continuously about the necessity of our understanding the politics and epistemology of media. For in the end, he was trying to tell us that what afflicted the people in *Brave New World* was not that they were laughing instead of thinking but that they did not know what they were laughing about and why they had stopped thinking.

**Material used in this test passage has been adapted from the following source:**

N. Postman, *Amusing Ourselves to Death: Public Discourse in the Age of Show Business*. ©1985 by N. Postman.

- 78.** The assertion that the introduction of an alphabet changes cognitive habits is:
- A) true, on the basis of the low literacy rate in the U.S.
  - B) supported by objective data in the passage.
  - C) perhaps true but not explicitly supported by passage information.
  - D) contradicted by the assertion that television watching is pervasive in the U.S.
- 79.** Which of the following findings would most *weaken* the author’s argument about the extent to which U.S. society has fulfilled the Huxleyan prophecy?
- A) A high percentage of the U.S. adults who watch television regularly have a good understanding of the politics and validity of the media.
  - B) A high percentage of the U.S. adults who watch television regularly failed to vote in the last presidential election.
  - C) More U.S. adults are able to name the judge on the television show “The People’s Court” than are able to name the U.S. chief justice.
  - D) More U.S. adults have read *1984* than have read *Brave New World*.
- 80.** The passage suggests that if a news commentator presented an editorial agreeing with the Huxleyan warning, many viewers would:
- A) take whatever action was necessary to combat the danger.
  - B) listen carefully to the commentator and then explain the ideas to others.
  - C) charge that the commentator was irrational or needlessly alarming viewers.
  - D) be receptive to learning more about the danger.
- 81.** One can justifiably infer from the author’s argument that if a presidential election campaign in the U.S. involved trivial candidates and discussion, the public would:
- A) vote for the candidates they found to be most trivial.
  - B) vote for the candidates they found to be least trivial.
  - C) denounce the entire campaign.
  - D) not even notice the triviality.
- 82.** The author sees the U.S. “consuming love affair” with television as relevant to Huxley’s warning because:
- I. television discusses vital matters.
  - II. television is changing people’s way of thinking.
  - III. technology can cause negative social changes.
- A) I only
  - B) II only
  - C) I and II only
  - D) II and III only
- 83.** A study concluding that political experts consider the U.S. presidential election a personality contest rather than a clash of issues would:
- A) support the author’s point that public business has become another aspect of entertainment.
  - B) support the author’s point that no one is warning the U.S. public of the Huxleyan nightmare.
  - C) suggest that Orwell was right in saying that Big Brother is watching people.
  - D) suggest that people believe in the inevitability of progress.

## Passage II

We must first make a distinction between literature and literary study. The two are distinct activities: One is creative, an art; the other, if not precisely a science, is a species of knowledge or of learning. There have been attempts, of course, to obliterate this distinction. For instance, it has been argued that one cannot understand literature unless one writes it, that one cannot and should not study Pope without trying one's own hand at heroic couplets or an Elizabethan drama without writing a drama in blank verse.

Yet useful as the experience of literary creation is, the task of the student is completely distinct. The student must translate the experience of literature into intellectual terms, assimilate it to a coherent scheme which must be rational if it is to be knowledge. It may be true that the subject matter is irrational, or at least contains strongly unrational elements; but the student of literature will not be therefore in any other position than the historian of painting or the musicologist or, for that matter, the sociologist or the anatomist. . . .

The problem is one of how intellectually to deal with art, and with literary art specifically. Can it be done? And how can it be done? One answer has been: It can be done with the methods developed by the natural sciences, which need only be transferred to the study of literature. Several kinds of such transfer can be distinguished. One is the attempt to emulate the general scientific ideals of objectivity, impersonality, and certainty, an attempt which on the whole supports the collecting of neutral facts. Another is the effort to imitate the methods of natural science through the study of causal antecedents and origins. . . . Scientific causality is used to explain literary phenomena by the assignment of determining causes to economic, social, and political conditions. Again, there is the introduction of the quantitative methods appropriately used in some sciences—i.e., statistics, charts, and graphs. And finally there is the attempt to use biological concepts in the tracing of the evolution of literature.

Today there would be almost general recognition that this transfer has not fulfilled the expectations with which it was made originally. . . .

There is, no doubt, a large field in which the methodologies of science and literary study contact or even overlap. Such fundamental methods as induction and deduction, analysis, synthesis, and comparison are common to all types of systematic knowledge. But patently the other solution commends itself: Literary scholarship has its own valid methods, which are not always those of the natural sciences but are nevertheless intellectual methods.

Only a very narrow conception of truth can exclude the achievements of the humanities from the realm of knowledge. Long before modern scientific development, philosophy, history, jurisprudence, theology, and even philology had worked out valid methods of knowing. Their achievements may have become obscured by the theoretical and practical triumphs of the modern physical sciences, but they are nevertheless real and permanent and can, sometimes with some modifications, easily be resuscitated or renovated. It should be simply recognized that there is this difference between the methods and aims of the natural sciences and the humanities.

**Material used in this test passage has been adapted from the following source:**

R. Wellek & A. Warren, *Theory of Literature*. ©1977 by R. Wellek and A. Warren.

**84.** What is the main idea of the passage?

- A) Those who create literature understand it more completely than do those who only study it.
- B) The methodologies of science and the study of literature have many features in common.
- C) There are valid methods for studying literature that differ from the methods of science.
- D) The achievements of the humanistic disciplines have been obscured by the achievements of the physical sciences.

85. According to the passage, the job of the student of literature is to:

- I. discover ways to approach literature intellectually.
- II. separate the rational from the irrational elements in literary works.
- III. integrate the experience of literature as art and the analysis of literature as knowledge.

- A) I only
- B) II only
- C) III only
- D) I and II only

86. The author suggests that both art history and musicology should be approached:

- A) with a strict scientific methodology.
- B) only by those who practice the art form.
- C) intellectually, despite their irrational components.
- D) with the understanding that they are essentially inaccessible to rational study.

87. Assume that a scholar is planning an extensive study of the children's story, *Red Riding Hood*. The author of the passage probably would say that the most important task to be performed is:

- A) examining the social context in which the story was written.
- B) comparing the occurrence of words indicating various concepts (family relationships, food, emotional states, etc.).
- C) tracing prior literary influences on the structure of the story and its influence on later works.
- D) isolating the story elements that explain its enduring popularity.

88. The reader can infer from the passage that its author believes that the use of "induction and deduction, analysis, synthesis, and comparison" in the study of literature is:

- A) appropriate, because such methods are common to all intellectual disciplines.
- B) appropriate, because no certainty about a subject is possible unless information about it is obtained objectively and quantitatively.
- C) inappropriate, because literature, unlike science, includes irrational aspects that cannot be investigated systematically.
- D) inappropriate, because of the different purposes of the sciences and the humanities.

89. If the author of the passage wants to get the most convincing evidence for passage assertions, the author should:

- A) investigate the process of creating a literary work.
- B) use the scientific method to study irrational elements in a literary work.
- C) apply a particular scientific technique to both a literary work and a problem in the natural sciences.
- D) compare a literary analysis and a scientific analysis of a literary work.

90. How could the author best clarify the statement that literature is "irrational, or at least contains strongly unrational elements"?

- A) By providing definitions of both *irrational* and *unrational*
- B) By giving an example of an unrational element in a specific work of literature
- C) By discussing the irrationality of the creative process
- D) By adding the explanation, "Human behavior is irrational; therefore stories depicting the truth of human behavior are likely to seem unrealistic."

**91.** The passage suggests that the author believes the study of literature to be important because it:

- A) shows that the scientific method can be applied to a wide variety of disciplines.
- B) helps the student to become more creative.
- C) teaches that the truth can be discovered by nonscientific means.
- D) offers a type of knowledge unavailable from other disciplines.

**92.** Assume that contemporary literary studies involving a systematic analysis of text have yielded evidence of underlying attitudes that traditional literary criticism had not detected. How does this assumption relate to assertions made in the passage?

- I. It is consistent with the assertion that the transfer of the methods of the natural sciences to art has not fulfilled expectations.
- II. It constitutes evidence for the assertion that there is a field in which the methodologies of science and literary study overlap.
- III. It is inconsistent with the assertion that philosophy, history, and theology have worked out valid methods of knowing that can be modified to apply to the humanities.

- A) I only
- B) II only
- C) I and III only
- D) II and III only

**93.** Elsewhere, the author says that “literature is no substitute for sociology or politics,” nor is it “substitute philosophy.” This statement agrees most closely with the passage assertion that:

- A) literary works are sometimes studied in relation to economic, social, and political conditions.
  - B) literary study has its own unique justifications and aims.
  - C) unlike sociology, politics, or philosophy, literature is an artistic pursuit.
  - D) the methodologies of science and literary study often overlap.
-

### Passage III

Should we one day awake to find a silver saucer floating over the White House, Earthlings would have little choice but to pay heed. But if an alien contact occurred by radio, humanity would face the momentous choice of whether to reply. The decision could turn on speculation about what the other beings were like.

We know from science fiction that all extraterrestrials speak English, with a Midwestern accent, that the men wear flowing metallic robes and the women wear brass bikinis, and that not a single alien in the entire expanse of the galaxy can shoot straight. . . . Researchers, though, have another article of faith: that extraterrestrials will not be hostile. . . . “Civilizations that don’t acquire the wisdom to control war will destroy themselves long before they can take to space, so the ones who are trying to contact you would be, by definition, no longer menacing.” . . .

Contact with an alien civilization might be cause for celebration merely because it could demonstrate that nuclear knowledge can be acquired without setting in motion Armageddon. But the alternatives to Armageddon aren’t automatically blissful. An alien civilization might avoid self-destruction by means abhorrent: global dictatorship, mind control, any number of unpleasant possibilities. . . .

James Trefil of George Mason University has cautioned that if evolution functions approximately the same way on other worlds that it has functioned here—conferring survival on the fittest—advanced extraterrestrials might still be aggressive, territorial, and quick to reach for the sword. . . . The most disquieting aspect of natural selection as observed on Earth is that it channels intellect to predators. Most bright animals are carnivores: Stalking requires tactics, pattern recognition, and for social animals, coordinated action, all incubators of brainpower. Although the martial heritage of [humanity] has been exaggerated in popular fiction . . . it’s reasonably certain that the forebears of modern *Homo sapiens* were hunters, and it’s definite that [humanity] has

been savage during the historical era. This isn’t much of a testimonial to “intelligence.”

Can we hope that on other worlds creatures other than predators have proved dominant? Yes. Not all selection pressures favor predation. The beaver has highly evolved dam-building talents designed to make habitats, not to corner prey; the transcontinental migratory skills of some birds are unrelated to killing. An extraterrestrial intelligence descended from a herding beast, [the] ancient instinctual imperative [of which] was to sacrifice for the common defense rather than to attack, might find a notion like mutually assured destruction as curious as military tacticians find [pacifists].

In other ways, though, the thought that natural selection might function on other worlds as it has on ours is comforting, for [it] would imply that “human” nature was something deeper even than we know. Aliens . . . might exhibit many recognizable traits: curiosity, desire for companionship, love of laughter, pleasure in art and culture, and respect for the sanctity of life.

Speculation about alien contact usually centers on culture shock, invasion scares, and technological secrets that might be unlocked. A stock assumption is that the first question we would send to an extraterrestrial radio operator would be something like “How do you build a 10,000-megajoule charged-particle beam?” Consider the ramifications if instead the question were [about their philosophy].

**Material used in this test passage has been adapted from the following source:**

G. Easterbrook, Are we alone? ©1988 by The Atlantic Monthly.

**94.** According to the passage, the application of the concept of natural selection to extraterrestrials could be disquieting in its suggestion that:

- A) the most intelligent beings may also be the most aggressive.
- B) not all selection pressures favor predation.
- C) extraterrestrials are intellectually superior to humans.
- D) extraterrestrials may exhibit many recognizable human traits.

**95.** According to the passage, speculation about the nature of extraterrestrials would be most crucial to humans in a situation in which:

- A) extraterrestrials landed unannounced on Earth.
- B) humans had the choice of whether to reply to an extraterrestrial contact.
- C) extraterrestrials were hostile to humans.
- D) humans could acquire nuclear knowledge without risking self-destruction.

**96.** In stating that alien civilizations might avoid self-destruction through “abhorrent” means, the author apparently intends to counter the views of:

- A) James Trefil.
- B) science-fiction writers.
- C) the researcher quoted in the second paragraph.
- D) military tacticians.

**97.** According to the author, one comforting aspect of the concept of natural selection in reference to extraterrestrials is the possibility that any extraterrestrials that contacted Earth would:

- A) represent the fittest of their species.
- B) exhibit recognizably “human” traits.
- C) counter the stereotypes of extraterrestrials promoted by science fiction.
- D) explain to us their means of avoiding nuclear destruction.

**98.** Given the information in the passage, one would expect the nature of an alien civilization that contacted Earth to be:

- A) either warlike or pacifistic.
- B) warlike by definition.
- C) pacifistic by definition.
- D) ethologically backward.

**99.** Assume that the first extraterrestrials to contact Earth are a formerly warlike species that became pacifistic after suffering the consequences of a horrible war. This scenario most strongly supports the characterization of extraterrestrials favored by:

- A) James Trefil.
  - B) the author of the passage.
  - C) the researchers mentioned in the second paragraph.
  - D) science-fiction writers.
-

## Passage IV

Late in 1987 . . . fourteen humpback whales died in Cape Cod Bay . . . during a five-week period. This die-off . . . was not a stranding, in which healthy whales beach themselves. Instead the cetaceans died at sea . . . and then washed ashore. Postmortem examinations showed that the whales had been well immediately before their deaths and that many of them had abundant blubber and fish in their stomachs, evidence of recent feeding. Alarmed and saddened, the public and press blamed pollution or a chemical spill for the mysterious deaths. . . .

We now know that [this event was] caused, either directly or indirectly, by toxic single-celled algae. . . . Certain blooms of algae are termed red tides when the tiny pigmented plants grow in such abundance that they change the color of the seawater to red, brown, or even green. The name is misleading, however, because many toxic events are called red tides even when the waters show no discoloration. Likewise, an accumulation of nontoxic, harmless algae can change the color of ocean water. . . .

Of the thousands of living phytoplankton species that make up the base of the marine food web, only a few dozen are known to be toxic. . . . A bloom develops when these single-celled algae photosynthesize and multiply. . . . Barring a shortage of nutrients or light, or heavy grazing by tiny zooplankton that consume the algae, the population's size can increase rapidly. In some cases, a milliliter of seawater can contain tens or hundreds of thousands of algal cells. Spread over large areas, the phenomenon can be both visually spectacular and catastrophic. . . .

Algal toxins . . . cause mortalities as they move through the marine food web. . . . From the human health standpoint, it is fortunate that herring, cod, salmon, and other commercial fish are sensitive to these toxins and, unlike shellfish, die before toxins reach dangerous levels in their flesh. Some toxin, however, accumulates in the liver and other organs of certain fish, and so animals such as other fish, marine mammals, and birds that consume whole fish . . . are at risk. . . .

[Whales] would have received continual doses of toxin as they fed. . . . [During] a dive, the mammalian diving reflex channels blood and oxygen predominantly to the heart and brain. . . . Each dive then would expose the most sensitive organs to the toxin, which would bypass the liver and kidney, where it could be metabolized and excreted. . . . The exact cause will never be known, but the evidence strongly suggests that these magnificent creatures died from a natural toxin originating in microscopic algae. . . .

Problems from harmful red tides have grown worse over [recent] decades. The causes, however, are multiple, and only some relate to pollution or other human activities. For example, the global expansion in aquaculture means that more areas are monitored closely, and more fisheries' products that can be killed or take up toxins are in the water. Likewise, our discovery of toxins in algal species formerly considered nontoxic reflects the maturation of this field of science, now profiting from more investigators, better analytical techniques and chemical instrumentation, and more efficient communication among workers.

Long-term studies . . . do show that red tides . . . are increasing as coastal pollution worsens. . . . [The] data demonstrate what should be an obvious relationship: Coastal waters receiving industrial, agricultural, and domestic waste, frequently rich in plant nutrients, should experience a general increase in algal growth. . . . [All] phytoplankton species, toxic and nontoxic, benefit, but we notice the enrichment of toxic ones more. Fertilize your lawn, and you get more grass—and more dandelions.

**Material used in this test passage has been adapted from the following source:**

D. M. Anderson, Red tides. ©1994 by Scientific American.

**100.** The author implies that the reason red tides are difficult to control is that:

- A) phytoplankton can multiply rapidly, covering extensive areas.
- B) the presence of toxicity in seawater is likely to remain undetected.
- C) the toxins increase to dangerous levels within the bodies of small fish.
- D) human pollution of seawater is not adequately monitored.

**101.** Assume that a committee of environmentalists who are aware of the information in the passage is appointed to advise Congress on ways to reduce the problem of red tides. The members would probably recommend that:

- A) fisheries release their products only in areas that are free of algae.
- B) whales and other important marine life be driven away from affected areas.
- C) herbicides be used to destroy all toxic species of algae.
- D) plant nutrients be removed from wastewater before it is released into waterways.

**102.** If the author's information is correct, and if the trends mentioned continue, which of the following changes can be expected?

- A) The consumption of fish will become increasingly dangerous to humans.
- B) The prevalence of large-scale die-offs of fish will increase.
- C) The relative number of algal species that are harmless will decrease.
- D) The number of shellfish in coastal waters will decrease.

**103.** Assume that a worldwide epidemic, especially severe among people in countries with a seacoast, is traced to poisoning by red-tide toxins. What is the most reasonable explanation of this phenomenon?

- A) Public anxiety in countries bordering oceans has increased their demand for medical attention.
- B) Contamination has spread to coastal areas in which people swim.
- C) Food fish have developed increased resistance to the toxins.
- D) Whales and other marine mammals are avoiding the toxic algae.

**104.** Which of the following findings would suggest that the author's concern about the danger of red tides is *exaggerated*?

- A) The whales that died in 1987 succumbed to dramatic fluctuations in water temperature.
  - B) Chemical spills in the vicinity of the dead whales had caused an extreme level of contamination.
  - C) Red tides occur rarely, are easily identified, and grow slowly.
  - D) A readily available substance is an effective antidote to red-tide poisoning.
-

## Passage V

Literary historians tell two stories about the novel in America before the Civil War. First, the Puritan tradition, enhanced by Scottish common sense philosophy, created an atmosphere hostile to fiction. Second, the sparseness of American social life made conventional novels difficult, even impossible, to write. These two narrative strands led to a single conclusion. The would-be American novelist before the Civil War was drawn, or forced, toward a literary form better suited to American imaginative space: the romance, created in an ambience of isolation, alienation, defiance, and apology that left its traces in the work.

This powerful critical myth, which at least since the 1950s has controlled our understanding of the novel in America, does not hold up well under empirical investigation. For one thing, expressed hostility to fiction was no less strong in England than in America; much of what Americans wrote and said about novels was derived from sources written in the British Isles. Scottish common sense philosophy should not be described as an American phenomenon. Second, the “conventional” novel at that time was only in the process of becoming conventional. Third, a great many novels were written and published in America at this time of supposed hostility to fiction, and a great many more were being read.

Book reviews published between 1840 and 1860 in major American periodicals offer evidence of American readers’ interest in fiction. In the 1840s, the periodical press in America came into its own. There were fewer than 125 American magazines in 1825; by 1850 there were about 600, with most of the expansion occurring in the 1840s. Many of these magazines were local or specialized in their appeal, but a few dozen, by virtue of their circulation, influence, or national scope, are properly called “major.” Some journals passed the 100,000 subscriber mark in the 1850s (a number that would extrapolate to over a million today), including *Harper’s*, *Godey’s*, *Peterson’s*, and the *Ledger*, while Horace Greeley’s *Tribune* in the aggregate of daily and weekly editions surpassed 200,000 in 1858.

A survey of 21 major American periodicals published during all or part of this period, including the five mentioned above, reveals more than two thousand reviews of eight hundred separate novels, about half of them American in origin. The reviews ranged in length from a single sentence in an omnibus review article to articles of many pages devoted to a single book. More often than not, American novels were received warmly by reviewers; in fact, those on magazine staffs who set themselves up as guardians of critical integrity complained about indiscriminate puffery among reviewers rather than the opposite. Of course a review does not necessarily represent the notions of anybody except its author, and even many congruent reviews may express only the opinions of a particular group of interested people. But perusing reviews from this period reveals that novel reviewing was conducted in constant awareness of what people were reading, and was directed toward trying to understand the reasons for public preferences. The reviews offer guidance and correction in a way that suggests reviewers had a fairly precise idea of what they were guiding and correcting.

The small number of American fiction writers who are now called major did, evidently, have trouble supporting themselves as novelists. But the explanation for this difficulty cannot be hostility in the public at large to fiction in general. The America into which Hawthorne launched *The Scarlet Letter* and Melville launched *Moby Dick* was a nation of novel readers.

**Material used in this test passage has been adapted from the following source:**

N. Baym, *Novels, Readers, and Reviewers*. ©1984 by Cornell University Press.

**105.** The primary purpose of the passage is to:

- A) identify the differences between two critical accounts of the growth of the novel in the U.S.
- B) trace the growth and influence of the magazine industry in the U.S. from 1840 to 1860.
- C) question the idea that the social and intellectual atmosphere in nineteenth-century America was hostile to fiction.
- D) offer contrary evidence to the argument that the Puritan tradition affected the growth of the romance in America.

**106.** Assume that nineteenth-century American publishers could acquire European novels as easily as American novels, and publish them at a higher profit. Would this information, if true, further the passage author's argument?

- A) Yes; it would make more impressive the fact that one-half of the periodical reviews from 1840 to 1860 were of American novels.
- B) Yes; it would reinforce the passage author's view that literary nationalism was not a viable force during this period.
- C) No; it would merely demonstrate that American publishers made profit a top priority.
- D) No; it would shed no light on the preferences of the American reading public for novels.

**107.** Which of the following assertions is NOT clearly supported by historical research provided by the passage author?

- A) Nineteenth-century American writers now considered major had difficulty supporting themselves by writing.
- B) Many novels were being written and read in the U.S. from the 1840s through the 1860s.
- C) American novels were well received by the major American periodicals of the mid-nineteenth century.
- D) The periodical press in the United States grew in size and influence during the 1840s.

**108.** What role does the sentence "Scottish common sense philosophy should not be described as an American phenomenon" play in the passage?

- A) It introduces a point that will be developed in detail later in the passage.
- B) It offers additional support for the points made in the preceding sentence.
- C) It reminds the reader that hostility to the novel originated abroad.
- D) It suggests that Scottish common sense philosophy was hostile to fiction.

**109.** Since the 1950s, some literary critics and historians have proclaimed the "death" of the conventional novel in America, attributing its demise to a widespread breakdown of social cohesiveness and an increase in individual isolation. This "death-of-the-novel" theory would be logically consistent with which aspect of the passage?

- A) The myth that the Puritan tradition made Americans hostile to the novel form
- B) The myth that the literary romance was compatible with the nineteenth-century American milieu
- C) The research findings on nineteenth-century book reviews of American novels
- D) The research findings on nineteenth-century attitudes toward the novel in England

**110.** If the information in the passage is accurate, which of the following would one LEAST expect to find in a randomly selected American magazine published between 1840 and 1860?

- A) An article lamenting the abundant reviews of novels by nineteenth-century American novelists
- B) An editorial decrying Americans' hostility to their own indigenous fiction
- C) A favorable review of a new American novel copied from a British periodical
- D) An essay reflecting the influence of Scottish common sense philosophy

- 111.** The author treats the ideas of “those on magazine staffs who set themselves up as guardians of critical integrity” as:
- A) credible evidence of prevailing attitudes.
  - B) questionable but intriguing possibilities.
  - C) amusing examples of wrongheaded thinking.
  - D) dangerously misinformed opinions.
- 112.** Passage information suggests that the “conventional” novel was:
- A) a well-established literary form by the early nineteenth century.
  - B) more common in England than in America.
  - C) similar in style and subject matter to the romance.
  - D) based on direct observation of social customs.
- 113.** Suppose lists of best-selling books had existed during the period under study. Which of the following pieces of information derived from such lists would be useful in evaluating the accuracy of the passage author’s conclusions?
- I. The degree to which reviewers’ conclusions about the relative popularity of different novels were accurate
  - II. The extent to which the length of the reviews a book received correlated with its popularity
  - III. The relative popularity of conventional novels and romances among American readers
- A) I only
  - B) III only
  - C) I and II only
  - D) I and III only

- 114.** *Wuthering Heights*, written by Englishwoman Emily Brontë in 1847, is considered by most literary scholars to be a romance. What is the relation between this fact and the main argument of the passage?
- A) It supports the passage argument by showing that the romance was not a uniquely American form.
  - B) It strengthens the passage argument by demonstrating that literary scholars are often mistaken in their conclusions.
  - C) It has little effect on the passage argument because the question of whether the romance is a distinctly American form is not crucial to the author’s point.
  - D) It undermines the passage argument because it suggests that an atmosphere of alienation had spread to England from America.
-

## Passage VI

It is not in the American experience to think about limits on energy. . . . Yet by the late 1960s and early 1970s, limits on the energy base in [the United States] began to surface. . . . Environmentalism made its influence felt in a large number of ways: in such legislation as the National Environmental Policy Act, the Clean Air Act, the Clean Water Act, and the Endangered Species Act; in the establishment of environmental impact statements; in the creation of the federal Environmental Protection Agency; and in the development of the significant new industry of pollution control.

As far as energy was concerned, environmentalism had its major [effect] on the burning of coal. Concern about air pollution led to fuel switching, especially by electric utilities, away from domestically produced coal to low-sulfur oil, which had to be imported. Although not particularly noticeable at the time, this change led to a significant increase in the demand for oil. Between 1968 and 1973, oil consumption by electric utilities more than tripled. Another limitation on [the U.S.] energy base was [that the] U.S. was an aging producer. It was outrunning its geological base. But this highly relevant fact was not represented in either the consumption pattern or in prices. . . . The turning point came in 1970, when U.S. oil production reached its peak and then began to decline. . . .

In terms of solving the supply side of the energy equation, the choices most talked about can be classified into two categories: hard versus soft energy paths. . . . The usual proposed hard-path solution is the rapid expansion of three sectors: coal (mainly strip-mined, then made into electricity and synthetic fluid fuels); oil and gas (increasingly from Arctic and offshore wells); and nuclear fission (eventually in fast-breeder reactors). Soft technologies, on the other hand, use to the greatest possible extent nondepletable resources like sun, wind, and vegetation. They emphasize diversification and dispersal of energy sources so as to avoid in the future the sort of dependence we now have on fossil fuels. . . .

An increasing number of individuals and communities in the U.S. are shifting to the soft path. . . . A more rapid spread of this approach is being hindered by government (taxpayer) subsidies of the hard-path approach, outdated building codes that discourage energy conservation and sometimes require unnecessary backup [by] conventional heating systems, inadequate access to capital for development of solar energy resources, and the false belief that it will be a long time before solar energy can provide a significant fraction of primary energy. In 1984, for example, about 18% of all primary energy used in the world and 8.5% of that used in the U.S. came from renewable solar energy resources. . . .

Diversification into solar energy is a primary reason for the dramatic acquisition of copper mines by oil companies. Each solar collector for heating and cooling systems requires about a pound of copper, and oil companies now control almost 60% of domestic copper production in the U.S. . . . Until recently, energy and high technology companies disparaged solar energy. . . . Worried that every rooftop could become its own power plant and sensing that the cry for solar energy was a revolt against huge companies, utilities, and staggering electric bills, large corporations spent a share of their public relations budget playing down the solar “messiahs.” At the same time, they began buying up solar technology companies.

**Material used in this test passage has been adapted from the following source:**

L. G. Brewster, *The Public Agenda: Issues in American Politics*.  
©1987 by St. Martin’s Press.

- 115.** Which of the following statements is *inconsistent* with information in the passage?
- A) Most people believe that the U.S. energy supply is nearly depleted.
  - B) Environmentalism has caused fundamental changes in the U.S. energy policy.
  - C) The use of domestic oil has been declining in the U.S. in recent years.
  - D) Since the 1970s, the U.S. government has consistently supported the soft-energy approach.

- 116.** The author of the passage probably most strongly supports:
- A) the acquisition of solar technology companies by large corporations.
  - B) increased utilization of low-sulfur oil by utility companies.
  - C) a switch to nuclear reactors as the primary energy source.
  - D) substantial federal subsidies for solar energy research.

- 117.** The author of the passage seems to hold the opinion that:
- A) U.S. utility companies are unresponsive to public environmental concerns.
  - B) the U.S. environmental movement has not fully confronted the energy problem.
  - C) large U.S. corporations act primarily according to the profit motive.
  - D) the U.S. Congress is committed to reforming the country's energy policy.

- 118.** Which of the following forms of legislation would an advocate of the soft-energy path probably support?
- I. Tax credits for corporations that install solar panels in office buildings
  - II. A mandate to increase the ratio of soft-to hard-energy sources by a specified amount within ten years
  - III. Cash incentives to homeowners who convert their heating systems from oil to natural gas

- A) I only
- B) I and II only
- C) I and III only
- D) II and III only

- 119.** Which of the following inferences is justified by information in the passage?

- A) The U.S. leads the world in the use of solar energy.
- B) The burning of imported oil pollutes the air less than does the burning of coal.
- C) Oil companies have a global monopoly on copper production.
- D) The consumption of natural gas has declined in the U.S. since the 1970s.

- 120.** Assume that the soft-energy path is fully implemented in the U.S. by the year 2025. Which of the following phenomena will be considered most outdated at that time?

- A) Rows of windmills along the seacoasts
- B) Houses designed and insulated to conserve energy
- C) Automobiles powered by liquid fuel distilled from corn
- D) Antipollution devices on the smokestacks of factories

- 121.** Suppose that an inventor has perfected a solar battery that would allow U.S. homeowners to convert rapidly and inexpensively from traditional electricity to solar power. The passage suggests which of the following scenarios as most probable?
- A) Utility companies attempt to purchase the patent on the battery.
  - B) The government provides business grants to encourage mass production of the battery.
  - C) Hard-path energy corporations publicly praise the invention.
  - D) The nuclear power industry lobbies for reduced taxes for customers who do not convert to solar power.

- 122.** Information in the passage suggests that which of the following changes would be most likely to accelerate U.S. progress along the soft-energy path?

- A) The price per barrel of imported oil rises from \$25 to \$50 within a few months.
  - B) An improved design for nuclear power plants makes radioactive leakage virtually impossible.
  - C) Coal-burning plants install furnaces that eliminate the emission of air pollutants.
  - D) Domestic oil production increases to the point that the U.S. is no longer dependent on imported oil.
-

## Passage VII

The institutions of the state generate a civil religion; so do the institutions of sport. The ancient Olympic games used to be both festivals in honor of the gods and festivals in honor of the state—and that has been the classical position of sports ever since. The ceremonies of sports overlap those of the state on one side and those of [religion] on the other. At the Super Bowl in 1970, clouds of military jets flew in formation, [U.S.] flags and patriotic bunting flapped in the wind, ceremonies honored prisoners of war, [clergy] solemnly prayed, thousands sang the national anthem. Going to a stadium is half like going to a political rally, half like going to [a religious gathering]. Even today, the Olympics are constructed around high ceremonies, rituals, and symbols. The Olympics are not bare-bones athletic events but religion and politics as well.

Most men and women don't separate the sections of their mind. They honor their country, go to [a place of worship], and also enjoy sports. All parts of their lives meld together. [Nearly] every writer about sports lapses into watery religious metaphor. So do writers on politics and sex. Larry Merchant says television treated the Super Bowl "as though it were a solemn High Mass." Words like *sacred*, *devotion*, *faith*, *ritual*, *immortality*, and *love* figure often in the language of sports. Cries like "You gotta believe!" and "life or death" and "sacrifice" are frequently heard. . . .

I am arguing a considerably stronger point. I am saying that sports flow outward into action from a deep natural impulse that is radically religious: an impulse of freedom, respect for ritual limits, a zest for symbolic meaning, and a longing for perfection. The athlete may of course be pagan, but sports are, as it were, natural religions. There are many ways to express this radical impulse: by the asceticism and dedication of preparation; by a sense of respect for the mysteries of one's own body and soul and for powers not in one's own control; by a sense of awe for the place and time of competition; by a sense of fate; by a felt sense of comradeship and destiny; by a sense of participation in the rhythms and tides of nature itself.

Sports, in the second place, are organized and dramatized in a religious way. Not only do the origins of sports, like the origins of drama, lie in religious celebrations; not only are the rituals, vestments, and tremor of anticipation involved in sports events like those of religions—even in our own secular age and for quite sophisticated and agnostic persons, the rituals of sports really work. They do serve a religious function: They feed a deep human hunger, place humans in touch with certain dimly perceived features of human life within this cosmos, and provide an experience of at least a pagan sense of godliness.

Among the godward signs in contemporary life, sports may be the single most powerful manifestation. I don't mean that participation in sports, as athlete or fan, makes one a believer in "God," under whatever concept, image, experience, or drive to which one attaches the name. Rather, sports drive one in some dark and generic sense "godward." In the language of Paul Tillich, sports are manifestations of concern, of will and intellect and passion. In fidelity to that concern, one submits oneself to great bodily dangers, even to the danger of death. Symbolically, too, to lose is a kind of death.

**Material used in this test passage has been adapted from the following source:**

M. Novak, *The Joy of Sports*. ©1976 by M. Novak.

**123.** The primary message of the passage is that one should:

- A) understand the profound importance of sports.
- B) appreciate the religious history of sports.
- C) recognize the patriotic impulses in sports.
- D) distinguish between the ceremony and the excitement of sports.

**124.** A probable reason for the use of the word “godward” is the author’s:

- A) faith in a divine presence that is apparent in daily life.
- B) wish to use language that includes all persons, whatever their views on religion.
- C) awareness of the similarity of popular spiritual movements to conventional religions.
- D) opinion that attendance at sporting events will lead to a religious revival.

**125.** The reference to “the classical position” of sports suggests that the author:

- A) respects the devoutness and patriotism of athletes.
- B) admires the skill of the athletes of ancient Greece.
- C) understands the historical function of athletics.
- D) accepts the domination of athletics by religion and politics.

Which of the following findings would most

**126.** *weaken* the author’s assertions about the value of sports in the U.S. culture?

- A) People would rather attend religious ceremonies than sporting events.
- B) Sports fans fail to recognize the religious impulse in their enthusiasm.
- C) Only the conventionally religious experience the spiritual dimension of sports.
- D) Players on a team have stronger feelings about the sport than do fans of the team.

**127.** The statement “to lose is a kind of death” is an example of the author’s emphasis on the:

- A) extent of the emotional investment in sports.
  - B) importance of honoring losers as well as winners.
  - C) unacceptability of losing a sporting competition.
  - D) consequences of an exaggerated concern with sports.
-

## Passage VIII

It is widely believed that mental phenomena are a special kind of physical phenomena. [Behaviorism] represents one form this opinion can take, holding that mental phenomena are behavioral dispositions or tendencies. In this view, a pain in the big toe consists of a set of dispositions to favor the big toe in certain ways, including the disposition to act in ways that might remove the toe from extremes of temperature or pressure and the disposition to complain about the big toe. Similarly, the belief that it is going to rain consists of dispositions to act as if it was going to rain. . . .

[The analyses suggested by] behaviorism of this simple sort . . . do not work. You may have a pain in your toe without having a disposition to complain or move your toe because you may be a super Spartan who does not want to give any sign of what you are feeling. Many critics would object more controversially that behaviorism takes too external a view of the mental. According to these critics, mental states and processes are not behavioral dispositions; they are the internal states and processes that are responsible for relevant behavioral dispositions.

Now it seems clear that states and processes [of] the brain are responsible for behavioral dispositions. So the only way in which mental states and processes can be responsible for behavioral dispositions is for them to be the very same as the underlying physical states and processes that are responsible for those behavioral dispositions. . . . If pain equals what is responsible for pain behavior and (to oversimplify matters) the firing of C-fibers equals what is responsible for pain behavior, then pain equals the firing of C-fibers.

A type-type identity theory holds that every type of mental [experience], such as pain, is identical to a corresponding type of physical [event], such as the firing of C-fibers. It is controversial whether this is an overly strong thesis because of its implication that the physical basis for any type of mental [experience] must be the same in different creatures. A [weak form of] functionalism allows that pain might be the firing of C-fibers in people and a different event in other creatures. Functionalism holds that mental events of a

certain sort are to be identified as those underlying events, whatever they are, that function in the relevant way. . . . According to functionalism, it does not matter what mental states and processes are made of, any more than it matters what a carburetor or heart or chess king is made of. . . .

An important aspect of functional notions is that they are defined in relation to a whole system of interdependent functions. To understand . . . a heart . . . you have to understand its function as a pump, which requires understanding . . . the function of the circulation of blood . . . in relation to other functional processes. . . . Similarly, to understand [the way] beliefs function, you have to understand [the way] beliefs function in relation to desires, intentions, perception, emotion, and inference. . . .

This is one reason [that] crude behaviorism must fail. A particular belief taken by itself cannot be identified with particular behavioral dispositions because the relevant behavioral dispositions are determined by various beliefs taken together plus various desires and other mental states. Whether you are disposed to take your umbrella with you depends not just on your belief that it will rain but also your desire not to get wet, your perception of the umbrella in the corner, your further belief that umbrellas are good for keeping rain off, and so on.

**Material used in this test passage has been adapted from the following source:**

G. Harman, Some philosophical issues in cognitive science: Qualia, intentionality, and the mind-body problem. ©1989 by MIT.

**128.** The passage suggests that behaviorism and type-type identity theory share which of the following weaknesses?

- A) They oversimplify mental states by reducing them to physiological states.
- B) They provide no reason for the existence of pain or other mental states.
- C) They ignore the context provided by associated beliefs and feelings.
- D) They assume that all mental events are determined by external physical events.

**129.** In 1979, opioid peptides, which produce pain relief in humans, were found in earthworms. According to passage information, someone who argues on the basis of this evidence that earthworms may be capable of feeling pain is most likely to be a:

- A) behaviorist.
- B) type-type identity theorist.
- C) functionalist.
- D) nonscientist.

**130.** The author apparently believes that “crude behaviorism”:

- A) does not take internal context sufficiently into account.
- B) should be replaced by type-type identity theory.
- C) can explain only actions that are predictable.
- D) assumes that beliefs and feelings do not exist.

**131.** Suppose that a mountain climber is offered a replacement for the rope by which the climber is suspended. If the climber accepts the replacement rope, with which of the following conclusions about this acceptance would the author be LEAST apt to agree?

- A) It constitutes evidence of a belief in the weakness of the original rope.
- B) It is one of many possible results of a belief in the weakness of the original rope.
- C) It is probably influenced by beliefs other than a belief in the weakness of the original rope.
- D) It indicates the operation of brain processes associated with changing ropes while climbing.

**132.** If asked, most adults would affirm that giraffes do not wear hats in the wild. Such beliefs are apparently constructed from relevant general knowledge rather than stored as explicit information. Is the conclusion that certain beliefs are only implicit consistent with functionalism as the author explains it?

- A) Yes, because implicit beliefs come into existence when there is a need for them
  - B) Yes, because implicit beliefs are underlying physical events rather than dispositions to behave
  - C) No, because implicit beliefs are irrelevant to desires, intentions, perceptions, and feelings
  - D) No, because implicit beliefs have no function
-

## Passage IX

Available research in second-language study strongly supports the hypothesis that the processes Krashen and others have called acquisition (the unconscious formulation of grammatical principles) and learning (the conscious cognitive-based study of grammar) represent two systems for internalizing knowledge about language. . . . [Activities] promoting acquisition are indispensable for all students. Learning activities are more limited in their usefulness to beginners. . . .

Overwhelming research evidence and informal reports point out that students who wish to communicate must acquire this ability in much the same way that speakers, adults or children, acquire it in natural situations. Krashen provides strong evidence that learned, rather than acquired, rules are of limited use to the student; for some, they serve as a monitor—i.e., primarily an “editor” to make minor changes or corrections in utterances which for the most part are initiated by acquired knowledge. Research supports Krashen’s hypothesis that this monitor can be activated only under restricted circumstances. The speakers must: (1) know the rule; (2) be focused on the form of what they are saying; and (3) have time to apply the rule.

Most speakers meet conditions for monitoring regularly and systematically only on cognitive grammar tests. Most of us are not able to monitor to an appreciable degree in normal communicative situations. Thus, even if rules are learned by students through explanation, drill, and practice, and even if they demonstrate that they can produce correct forms and syntax on grammar exams, such (cognitively based) knowledge is usually not very helpful in normal communicative situations, particularly in the beginning stages. Krashen’s monitor theory thus explains that oral proficiency in communication is not necessarily related to the ability to achieve high scores on standard grammar tests, a fact usually overlooked by language teachers who claim to have communicative competence as a goal but continue to evaluate progress only in the learning of grammar rules.

Krashen claims that the monitor theory also accounts for the tremendous variation in grammatical accuracy among adults. There are “underusers,” those who rarely use their learned competence or perhaps those whose learned competence is low. (“Underusers” might still achieve very high levels of communicative accuracy entirely through acquisition.) “Overusers” spend so much time and effort on correctness that it often seriously interferes with communication. “Optimal users” are those who are able to monitor their speech and improve their level of grammatical accuracy, but not to such an extent that it interferes with smooth communication.

A fourth category was suggested by Carlos Yorio . . . “superusers,” those who are consciously able to apply learned rules quickly and efficiently so that a listener would not notice the monitoring at all. Many language instructors fall into this category, and although most have acquired the relevant rules through subsequent experience and no longer need to monitor their speech consciously, they often feel that this mode of production (supermonitoring) is the most efficient way to learn another language. Unfortunately, many, perhaps most, students are not capable of performing with the mental gymnastics of their supermonitor instructors. . . .

Fortunately, a conscious understanding of grammar rules is not a prerequisite to their acquisition. Most adults are not very good at learning grammar, but they acquire rules readily, although usually imperfectly, given the chance to interact in communicative situations with native speakers of the target language.

**Material used in this test passage has been adapted from the following source:**

T. D. Terrell, *The Natural Approach to Language Teaching: An Update*. ©1983 by Newbury House Publishers.

**133.** According to the author's description of the monitor theory, learned rules are most useful when a student of a second language is:

- A) showing the habits of an underuser.
- B) beginning to study the language.
- C) taking a grammar test.
- D) attempting to engage in conversation.

**134.** According to the author, Krashen would classify people who frequently correct their own grammar while speaking as:

- A) superusers.
- B) overusers.
- C) optimal users.
- D) underusers.

**135.** Which of the following findings about the value of grammar tests would be most *troublesome* for the monitor theory?

- A) The scores of beginning language students are good predictors of their oral proficiency.
- B) The scores of beginning language students are poor predictors of their oral proficiency.
- C) The scores of language instructors are good predictors of their oral proficiency.
- D) The scores of language instructors are poor predictors of their oral proficiency.

The author states that underusers might

**136.** “achieve very high levels of communicative accuracy entirely through acquisition”. Which of the following items of information provided elsewhere in the passage most helps to clarify this statement?

- A) Children develop their ability to speak in informal situations.
- B) Learned rules of grammar have limited usefulness for language students.
- C) Some people can apply learned rules so efficiently that their monitoring is not noticeable.
- D) Modifications of utterances are usually initiated by prior knowledge.

**137.** The passage suggests that an effective way for second-language learners to improve their fluency would be to:

- A) drill themselves repeatedly on everyday vocabulary.
  - B) use audiotapes to learn grammar while sleeping.
  - C) use the second language to request information.
  - D) perform mental exercises to increase their memory.
-

# Biological Sciences

Time: 100 minutes

Questions: 140 - 216

Most questions in the Biological Sciences test are organized into groups, each containing a descriptive passage. After studying the passage, select the one best answer to each question in the group. Some questions are not based on a descriptive passage and are also independent of each other. If you are not certain of an answer, eliminate the alternatives that you know to be incorrect and then select an answer from the remaining alternatives. Indicate your selected answer by marking the corresponding answer on your answer sheet. A periodic table is provided for your use. You may consult it whenever you wish.

---

This document has been encoded to link this download to your member account. The AAMC and its Section for the MCAT hold the copyrights to the content of this Practice Test. Therefore, there can be no sharing or reproduction of materials from the Practice Test in any form (electronic, voice, or other means). If there are any questions about the use of the material in the Practice Test, please contact the MCAT Information Line (202-828-0690).

# Periodic Table of the Elements

1 <b>H</b> 1.0																	2 <b>He</b> 4.0
3 <b>Li</b> 6.9	4 <b>Be</b> 9.0											5 <b>B</b> 10.8	6 <b>C</b> 12.0	7 <b>N</b> 14.0	8 <b>O</b> 16.0	9 <b>F</b> 19.0	10 <b>Ne</b> 20.2
11 <b>Na</b> 23.0	12 <b>Mg</b> 24.3											13 <b>Al</b> 27.0	14 <b>Si</b> 28.1	15 <b>P</b> 31.0	16 <b>S</b> 32.1	17 <b>Cl</b> 35.5	18 <b>Ar</b> 39.9
19 <b>K</b> 39.1	20 <b>Ca</b> 40.1	21 <b>Sc</b> 45.0	22 <b>Ti</b> 47.9	23 <b>V</b> 50.9	24 <b>Cr</b> 52.0	25 <b>Mn</b> 54.9	26 <b>Fe</b> 55.8	27 <b>Co</b> 58.9	28 <b>Ni</b> 58.7	29 <b>Cu</b> 63.5	30 <b>Zn</b> 65.4	31 <b>Ga</b> 69.7	32 <b>Ge</b> 72.6	33 <b>As</b> 74.9	34 <b>Se</b> 79.0	35 <b>Br</b> 79.9	36 <b>Kr</b> 83.8
37 <b>Rb</b> 85.5	38 <b>Sr</b> 87.6	39 <b>Y</b> 88.9	40 <b>Zr</b> 91.2	41 <b>Nb</b> 92.9	42 <b>Mo</b> 95.9	43 <b>Tc</b> (98)	44 <b>Ru</b> 101.1	45 <b>Rh</b> 102.9	46 <b>Pd</b> 106.4	47 <b>Ag</b> 107.9	48 <b>Cd</b> 112.4	49 <b>In</b> 114.8	50 <b>Sn</b> 118.7	51 <b>Sb</b> 121.8	52 <b>Te</b> 127.6	53 <b>I</b> 126.9	54 <b>Xe</b> 131.3
55 <b>Cs</b> 132.9	56 <b>Ba</b> 137.3	57 <b>La*</b> 138.9	72 <b>Hf</b> 178.5	73 <b>Ta</b> 180.9	74 <b>W</b> 183.9	75 <b>Re</b> 186.2	76 <b>Os</b> 190.2	77 <b>Ir</b> 192.2	78 <b>Pt</b> 195.1	79 <b>Au</b> 197.0	80 <b>Hg</b> 200.6	81 <b>Tl</b> 204.4	82 <b>Pb</b> 207.2	83 <b>Bi</b> 209.0	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)
87 <b>Fr</b> (223)	88 <b>Ra</b> (226)	89 <b>Ac†</b> (227)	104 <b>Unq†</b> (261)	105 <b>Unp</b> (262)	106 <b>Unh</b> (263)	107 <b>Uns</b> (262)	108 <b>Uno</b> (265)	109 <b>Une</b> (267)									
			* 58 <b>Ce</b> 140.1	59 <b>Pr</b> 140.9	60 <b>Nd</b> 144.2	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.4	63 <b>Eu</b> 152.0	64 <b>Gd</b> 157.3	65 <b>Tb</b> 158.9	66 <b>Dy</b> 162.5	67 <b>Ho</b> 164.9	68 <b>Er</b> 167.3	69 <b>Tm</b> 168.9	70 <b>Yb</b> 173.0	71 <b>Lu</b> 175.0	
			† 90 <b>Th</b> 232.0	91 <b>Pa</b> (231)	92 <b>U</b> 238.0	93 <b>Np</b> (237)	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (260)	

## Passage I

Bone consists of a hard mineral portion (mostly calcium), together with an organic, collagen-like matrix. Bone tissue contains about 99% of the body's calcium. Throughout life, bone is continuously resorbed and reformed—a process intimately related to the maintenance of an adequate level of calcium in the blood plasma. Some important agents that affect this process are:

*Parathyroid hormone*, which acts on bone tissue to encourage the formation and activity of osteoclasts (which break down bone cells) and to impair new bone formation.

*Vitamin D*, which in its activated form functions like a hormone. This nonpolar compound acts on the small intestine to stimulate absorption of calcium and also on bone tissue to enhance the effect of parathyroid hormone. It can be obtained from the diet or by the action of ultraviolet light on the skin.

*Calcitonin*, which decreases bone resorption; however, its effect is small (more like fine-tuning).

*Vitamin C*, which is required for the synthesis of bone matrix and is therefore needed for bone formation.

Two common diseases affect bone metabolism:

1. **Rickets** affects children, causing inadequate mineralization of new bone matrix. The ratio of mineral to organic matter is lower than normal. This abnormality can result in distortion of the bones, especially long bones, leading to bowed legs. It is caused by insufficient vitamin D activity.
2. **Osteoporosis** usually affects older people, most often postmenopausal women. There is more bone resorption than bone formation, resulting in a reduction of bone mass but a normal ratio of mineral to organic matter. The causes are not definitely known, although weight-bearing activity promotes bone mass increase, and lack of activity causes bone loss.

140. Which of the following conditions could produce rickets?
- I. Metabolic deficiency of parathyroid hormone
  - II. Impairment of conversion of vitamin D to its active form
  - III. Inability of the active form of vitamin D to act on its target tissue
- A) I only  
B) I and II only  
C) I and III only  
D) II and III only
141. Why do calcium supplements often include vitamin D?
- A) Vitamin D is needed to prevent rickets.
  - B) The activated form of vitamin D stimulates the absorption of calcium into the blood.
  - C) The activated form of vitamin D enhances the action of calcitonin.
  - D) The activated form of vitamin D enhances the uptake of calcium by bone tissue.
142. A low level of calcium in the plasma will trigger an increase of:
- I. osteoclast activity.
  - II. parathyroid hormone.
  - III. vitamin C.
- A) I only  
B) I and II only  
C) I and III only  
D) II and III only
143. Under what condition would the level of calcitonin tend to increase?
- A) When there is a dietary deficiency of calcium
  - B) When there is a dietary deficiency of vitamin D
  - C) When the level of calcium in the plasma is high
  - D) When the level of parathyroid hormone is too low

**144.** Which of the following persons would be most likely to have rickets?

- A) A child with a dietary deficiency in fat-soluble vitamins living in a tropical climate
- B) A child with a dietary deficiency in fat-soluble vitamins living in a northern climate
- C) A child with a dietary deficiency in water-soluble vitamins living in a tropical climate
- D) A child with a dietary deficiency in water-soluble vitamins living in a northern climate

**145.** What would be the result of complete removal of the parathyroid glands?

- A) Severe neural and muscular problems due to deficiency of calcium in the plasma
  - B) An increase in calcitonin production to compensate for calcium deficiency in the plasma
  - C) A drastic change in the ratio of mineral to matrix tissue in bones
  - D) Calcification of some organs due to accumulation of calcium in the plasma
-

## Passage II

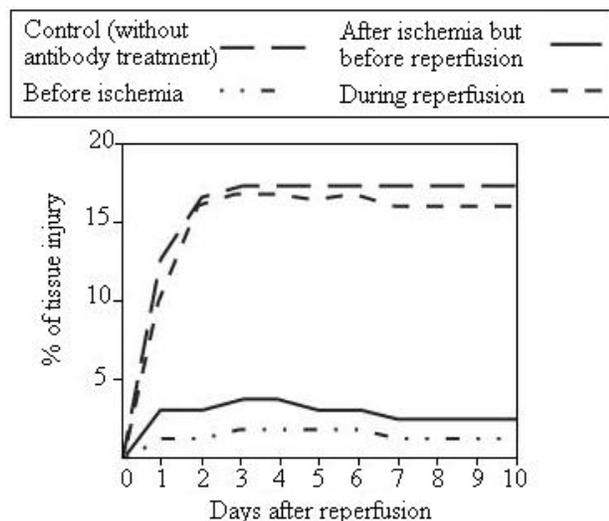
The tissue injury that results from ischemia (loss of blood flow) and subsequent blood reperfusion underlies several common, life-threatening disorders including heart attack, stroke, organ failure, and circulatory shock. Until recently, it was believed that the devastating tissue damage in these conditions resulted exclusively from anoxia (lack of oxygen).

A scientist observed that during these disorders, neutrophil cells (a type of leucocyte) adhered to the vascular endothelium and then migrated into surrounding tissues. The adherence of neutrophils was facilitated by an adhesion receptor on the neutrophil membrane. During reperfusion, adherent neutrophils released toxic products including oxygen-derived free radicals, proteases, and prostaglandin products. The scientist hypothesized that most of the tissue damage was actually a neutrophil-mediated phenomenon (i.e., the toxic products were the actual cause of tissue damage).

After extensive research, the scientist found that the neutrophil adhesion receptors are heterodimer molecules consisting of a beta subunit noncovalently associated with an alpha subunit. The two subunits were isolated from neutrophils and each was used to generate mouse antibodies. Antibody A was directed against the alpha subunit and antibody B was directed against the beta subunit. When these antibodies were applied to lab animals subjected to ischemia of the heart, only animals that received antibody B showed a great reduction in subsequent tissue injury; antibody A had no effect and the animals died. The scientist concluded that the majority of the injury was indeed caused by neutrophils.

146. Which of the following experiments would provide the best supporting evidence that neutrophils are the cause of the reperfusion injury?
- A) Performing the ischemia/reperfusion experiment using B (antibody-producing) cell-depleted animals and examining whether the degree of tissue damage is reduced
  - B) Performing the ischemia/reperfusion experiment using neutrophil-depleted animals and examining whether the degree of tissue damage is reduced
  - C) Repeating the experiment with another antibody directed against the entire alpha/beta heterodimer, and examining whether the degree of tissue damage is reduced
  - D) Repeating the experiment with another antibody directed against the beta subunit, and examining whether the degree of tissue damage is reduced
147. Information in the passage suggests *most strongly* that the function of the beta subunit involves:
- A) adhering neutrophils to the endothelium.
  - B) transferring proteinases from endothelium to neutrophils.
  - C) hydrogen bonding with the alpha subunit.
  - D) the generation of antibody against the subunit.

**148.** The scientist applied antibody B to lab animals at different stages during ischemia and reperfusion. The animals were then studied for 10 days, and the results are shown in Figure 1.



**Figure 1** Treatment of animals with antibody B at different time points during an ischemia/reperfusion experiment

The figure shows that the animals can be protected from tissue injury if the antibody treatment is received:

- A) at any time during ischemia or reperfusion.
- B) after reperfusion only.
- C) during reperfusion only.
- D) before reperfusion only.

**149.** The scientist claimed that antibody B offers a better means for preventing organ injury than agents such as free radical or protease inhibitors. Which of the following reasons offers the best support for this claim?

- A) Antibody B is a high-affinity antibody; therefore, it will not be rejected by the patient.
- B) Antibody B can block the initiation of events that result in the release of harmful, biologically active molecules.
- C) Antibody B is a very specific antibody; therefore, it will not recognize anything else other than the beta subunit.
- D) Antibody B exhibits a high half-life and can be used at any dosage at any time.

**150.** The scientist wanted to use antibody B clinically (i.e., to treat humans), but this proposal was rejected. Which of the following is the most logical reason for the rejection?

- A) Because the antibody was generated in the mouse, it can never be used in humans.
- B) Because the antibody was generated in the mouse, repeated usage in the same patient would elicit the production of human anti-mouse antibodies.
- C) Because the antibody was generated in the mouse, it will not recognize human antigens.
- D) Because the antibody was generated in the mouse, it can only be used in vitro.

**151.** Which of the following situations would most likely occur in patients with defects in the neutrophil adhesion receptors during bacterial infections?

- A) A presence of pus at sites of bacterial infections
- B) An absence of pus at sites of bacterial infections
- C) An increase in the amount of circulating red blood cells
- D) A decrease in the amount of circulating white blood cells

**152.** A neutrophil has point mutations in the genes coding for the alpha and the beta subunits of the adhesion receptor. However, this cell can still migrate through endothelium. Which of the following conclusions about the effect of this mutation can be drawn?

- A) The cell cannot release toxic products such as prostaglandins.
  - B) The cell has only functional beta subunits.
  - C) The cell can bind to endothelium.
  - D) The cell has a defective cell membrane.
-

### Passage III

Students conducted two experiments to study the reactivities of cyclohexanone and 2-furaldehyde. The rates of formation of their semicarbazones from semicarbazide at three temperatures were studied in Experiment 1. The stability of the respective semicarbazones was studied in Experiment 2. The products of kinetic and thermodynamic control were determined.

#### Experiment 1

Three flasks containing equimolar amounts of cyclohexanone and 2-furaldehyde in aqueous ethanol were maintained at 0°C, 25°C, and 85°C, and labeled A, B, and C, respectively. An aqueous, colorless solution of semicarbazide hydrochloride was prepared. One-third of the semicarbazide was added to each labeled flask to make Sample 1A at 0°C, Sample 1B at 25°C, and Sample 1C at 85°C. After 20 minutes, the samples were allowed to come to room temperature. Then, the crystals from each sample were collected, allowed to dry overnight, and the melting point of each crystalline product was obtained.

#### Experiment 2

A pure sample of the semicarbazone of cyclohexanone was mixed with a pure sample of 2-furaldehyde in one flask labeled 2D, and a pure sample of the semicarbazone of 2-furaldehyde was mixed with a pure sample of cyclohexanone in a second flask labeled 2E. Each flask was warmed and kept at 85°C for 20 minutes. Crystals were collected from the cooled flasks, dried overnight, and the melting point of each crystalline product was obtained. Table 1 shows the recorded melting point data.

**Table 1** Melting Point Data

Semicarbazone crystals	Melting point (°C)
Cyclohexanone (white)	166 (lit)
2-Furaldehyde (yellow)	202 (lit)
Expt 1A	158–164
Expt 1B	172–180
Expt 1C	197–201
Expt 2D	197–201
Expt 2E	197–202

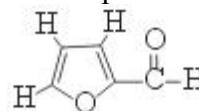
153. Which of the following rationales explains which compound is the product of kinetic control?

- A) Its semicarbazone has the lower melting point.
- B) It forms faster at all temperatures because its rate of formation is independent of its path.
- C) Its reaction profile has the lower energy of activation.
- D) Its reaction profile has the higher energy of activation.

154. Which semicarbazone is the product of thermodynamic control?

- A) Cyclohexanone's, because the more stable product forms faster
- B) Cyclohexanone's, because it contains more alkyl substituents to a double bond than does the other product
- C) 2-Furaldehyde's, because it is produced under equilibrium conditions and is more stable than the other product
- D) 2-Furaldehyde's, because its potential energy is higher

155. Based on its structure (shown below), the aldehydic proton in 2-furaldehyde should appear in its  $^1\text{H}$  NMR spectrum as a:



- A) singlet.
- B) doublet.
- C) triplet.
- D) quartet.

**156.** In each experiment, the crystals are collected on a Hirsch funnel and washed with two portions of cold water in order to:

- A) recrystallize the product.
- B) remove soluble impurities.
- C) remove insoluble impurities.
- D) spread the crystals evenly over the surface of the funnel.

**157.** What is the hybridization of the carbonyl carbon in cyclohexanone?

- A)  $s$
  - B)  $sp$
  - C)  $sp^2$
  - D)  $sp^3$
-

## Passage IV

A person has hypertension (high blood pressure) when his or her systemic arterial pressure exceeds the upper end of the normal range. Usually, hypertension includes pressures that are greater than 140/90 mmHg. A shortened life expectancy is associated with hypertension; thus, people with hypertension should be identified and treated. Unfortunately, most cases of hypertension have unknown causes and are described as essential hypertension. However, several hypotheses that account for essential causes of hypertension have been proposed. Two hypotheses are given here:

### *Hypothesis A*

An analog of Ohm's Law applied to the cardiovascular system illustrates the basic relationship between blood pressure ( $P$ ), flow rate of blood from the heart (cardiac output or  $CO$ ), and vascular resistance to the flow of blood ( $VR$ ):  $P = CO \times VR$ . Vascular resistance is predominantly a function of blood vessel radius. Therefore, an increase in systemic vascular resistance caused by factors such as vessel disease or enhanced muscle tone in the vessel walls (vasoconstriction) may be the major cause of systemic hypertension.

### *Hypothesis B*

Although increases in resistance to blood flow can quickly increase blood pressure, increased pressure should presently act to initiate an effective corrective reflex involving the kidneys. The increased pressure should cause the kidneys to increase their output of fluid, and this should bring the pressure back to normal despite the persistent elevation in vascular resistance. The nervous system is probably not involved in this reflex. Failure of this reflex function may cause systemic hypertension.

**158.** Assuming Hypothesis B to be correct, which of the following endocrine disorders would cause hypertension that could NOT be rectified by physiologically normal kidneys?

- A) An excess of aldosterone
- B) An excess of glucagon
- C) A shortage of thyroxine
- D) A shortage of insulin

**159.** What mechanism probably would be responsible for the increased urine output induced by hypertension according to Hypothesis B?

- A) Increased blood flow to the bladder
- B) Increased renal tubular reabsorption of solutes and water
- C) Increased collecting duct permeability to water
- D) Increased glomerular filtration rate

**160.** If restriction of blood flow to the kidneys (by placing clamps on the renal arteries) resulted in an immediate but small increase in blood pressure, followed by the gradual development of severe hypertension, which hypothesis would these results best support?

- A) Hypothesis A, because the clamps increased the vascular resistance to blood flow
- B) Hypothesis A, because the clamps caused the kidneys to receive less blood
- C) Hypothesis B, because the kidneys were responding to decreased glomerular blood pressure
- D) Hypothesis B, because the volume of body fluids was probably decreasing

**161.** If blood pressure doubled and the resistance to blood flow increased by 50%, the amount of blood pumped by the heart would have:

- A) increased by  $1/3$ .
- B) increased by  $1/2$ .
- C) decreased by  $1/3$ .
- D) decreased by  $1/2$ .

**162.** According to Hypothesis A, enhanced activity of which of the following basic muscle types would be most likely to cause hypertension?

- A) Striated
  - B) Smooth
  - C) Cardiac
  - D) Multinucleate
-

**These questions are not based on a descriptive passage and are independent of each other.**

**163.** Synthesis of antibody proteins in eukaryotic cells is associated with what organelle?

- A) Nucleus
- B) Mitochondrion
- C) Endoplasmic reticulum
- D) Golgi apparatus

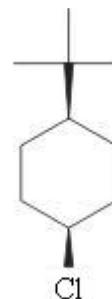
**164.** In the human "knee-jerk" reflex, the knee is struck and the lower leg jerks forward. Which of the following represents the complete pathway that the nerve impulse travels in effecting this response?

- A) Sensory neuron, motor neuron
- B) Sensory neuron, brain, motor neuron
- C) Sensory neuron, associative neuron, brain, associative neuron, motor neuron
- D) Sensory neuron, associative neuron, motor neuron, associative neuron, motor neuron

**165.** The most effective way to remove triethylamine during the workup of an organic reaction would be to extract the reaction mixture with aqueous:

- A) sodium bicarbonate.
- B) sodium bisulfite.
- C) sodium sulfate.
- D) hydrochloric acid.

**166.**



**Compound 1**

What is the orientation of the *tert*-butyl and chloro substituents, respectively, in the predominant conformation of Compound 1?

- A) Axial, axial
  - B) Axial, equatorial
  - C) Equatorial, axial
  - D) Equatorial, equatorial
-

## Passage V

In gout, an inflammatory reaction occurs in response to the deposition of solid uric acid in joints. Uric acid crystals form due to increased concentration of circulating uric acid. Phagocytosis of the uric acid crystals by infiltrating leukocytes leads to hyperactivation of the inflammatory cells. Joint damage occurs from the subsequent release of inflammatory agents from the leukocytes. Gout can be one of the sequelae of starvation, pneumonia, and leukemia, conditions characterized by increased breakdown of cells.

Humans excrete small amounts of uric acid in the urine, but in most other mammals, uric acid is further oxidized to allantoin before excretion. Uric acid is formed by the breakdown of purines to xanthine, a uric acid precursor, and by direct synthesis from 5-phosphoribosylpyrophosphate (5-PRPP) and glutamine. Allopurinol, an inhibitor of the enzyme xanthine oxidase, is one drug that is used to treat gout. Allopurinol's effectiveness is inversely related to substrate concentration, but the drug does not directly alter the xanthine oxidase turnover rate (maximum possible rate of the reaction when substrate concentration is not limited). Another drug used to treat gout is colchicine, an inhibitor of microtubule reorganization.

In one patient with recurrent gout, excreted uric acid levels were found to be three times normal levels. The patient's red blood cells exhibited markedly increased levels of 5-PRPP. Assays revealed that the patient had normal levels of PRPP synthetase, but the enzyme activity was three times normal levels in cultured cells. The pH optimum and the enzyme activity of the purified enzyme were normal. The patient was treated with colchicine, which alleviated some pain.

- 167.** Uric acid enters the urine both through filtration and secretion in the kidney. The process of filtration of uric acid in the kidney takes place in the:
- A) glomerulus.
  - B) loop of Henle.
  - C) distal convoluted tubule.
  - D) proximal convoluted tubule.
- 168.** Colchicine most likely relieves gout symptoms through what mechanism?
- A) Prevention of uric acid diffusion through cell membranes
  - B) Inhibition of leukocyte phagocytosis of uric acid crystals
  - C) Inhibition of uric acid crystal formation
  - D) Maintenance of the pH optimum for PRPP synthetase
- 169.** What nitrogenous base would promote the formation of uric acid crystals in gout?
- A) Cytosine
  - B) Uracil
  - C) Guanine
  - D) Thymine

**170.** In the patient described in the passage, the likely genetic basis of the increased levels of uric acid is a mutation:

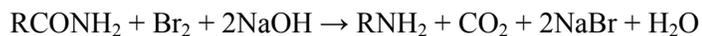
- A) affecting an allosteric site of PRPP synthetase.
- B) affecting the active site of PRPP synthetase.
- C) in a promotor gene regulating the rate of transcription of the PRPP synthetase gene.
- D) in a gene coding for a transcription factor for the PRPP synthetase gene.

**171.** Some animals have developed the ability to excrete nitrogenous waste largely in the form of uric acid, which is nontoxic and does not require large amounts of water for its excretion. Considering its lifestyle, what animal would excrete nitrogen primarily in the form of uric acid?

- A) Wild pig
  - B) Flying bird
  - C) Carnivorous shark
  - D) Herbivorous bony fish
-

## Passage VI

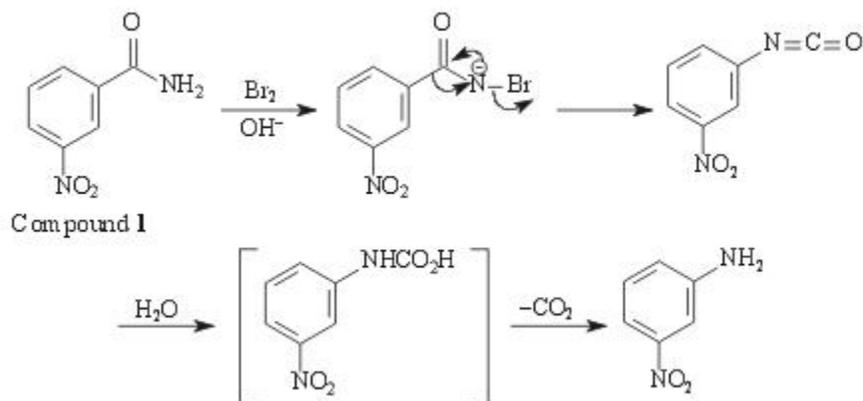
When a primary amide is treated with bromine or chlorine in the presence of a strong base, it can undergo a Hofmann rearrangement (Reaction 1). The result is the loss of the carbonyl carbon and the formation of an amine with one fewer carbon.



### Reaction 1

This process works well to prepare both aliphatic and aromatic amines. It is a good way to prepare primary amines, which are often difficult to synthesize by a simple nucleophilic substitution. The mechanism involves a base-promoted bromination as in Scheme 1 and results in the initial formation of an isocyanate which is hydrolyzed to the product amine.

A group of students synthesized *m*-nitroaniline using a Hofmann rearrangement by treating Compound 1 with bromine in aqueous base. The reaction was done at 80°C in order to minimize side reactions. The reaction was monitored by IR and the product was purified by extraction.

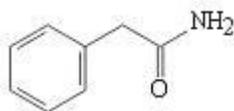


Scheme 1

**172.** The first step of the Hofmann rearrangement involves the abstraction of one of the protons on the nitrogen. The amide N–H proton is slightly acidic because the:

- A) resulting anion is resonance-stabilized.
- B) N–H bond is polar.
- C) aromatic ring is electron-donating.
- D) amide is not basic.

**173.** What is the major product when 2-phenylacetamide, below, is treated with bromine and aqueous base under the conditions in the passage?



- A)
- B)
- C)
- D)

**174.** It has been reported that under some conditions hydrolysis of the amide can compete with the Hofmann rearrangement. What product would be expected if this side reaction were important for Compound **1**?

- A) Benzamide
- B) 3-Nitroaniline
- C) 3-Nitrobenzamide
- D) 3-Nitrobenzoic acid

**175.** The students monitored the conversion of Compound **1** to *m*-nitroaniline by infrared spectroscopy. The disappearance of which band would indicate that the starting material had been consumed?

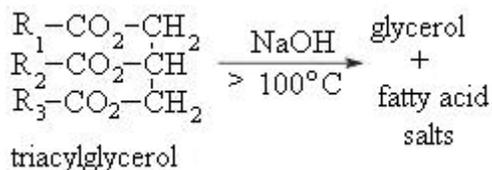
- A) 1550  $\text{cm}^{-1}$
- B) 1650  $\text{cm}^{-1}$
- C) 2200  $\text{cm}^{-1}$
- D) 3300  $\text{cm}^{-1}$

**176.** The conversion of Compound **1** to *m*-nitroaniline can also be monitored by  $^{13}\text{C}$  NMR spectroscopy. The disappearance of the signal at which frequency accompanies the consumption of the starting material?

- A) 65 ppm
  - B) 107 ppm
  - C) 120 ppm
  - D) 165 ppm
-

## Passage VII

*Saponification* is a procedure that involves the basic hydrolysis of esters. For example, when a triacylglycerol is saponified with NaOH, the products are glycerol (1,2,3-trihydroxypropane) and the salts of fatty acids (soaps), as shown in Reaction 1.



### Reaction 1

Researchers saponified a pure triacylglycerol and discovered that four fatty acid salts were produced instead of three. In order to identify the four salts, the researchers converted the salts into a mixture of fatty acid esters and analyzed the resulting mixture by gas chromatography.

**177.** When glycerol reacts with three different fatty acids, how many stereogenic centers does the product triacylglycerol contain?

- A) 0
- B) 1
- C) 2
- D) 3

**178.** Which of the following formulas represents a general structure of a fatty acid salt produced in Reaction 1? (Note:  $R_n = R_1, R_2,$  or  $R_3.$ )

- A)  $R_n-\text{CH}_2^- \text{Na}^+$
- B)  $R_n-\text{CH}_2\text{O}^- \text{Na}^+$
- C)  $R_n-\text{C}(\text{O})^- \text{Na}^+$
- D)  $R_n-\text{CO}_2^- \text{Na}^+$

**179.** Which of the following is the most plausible explanation for the fact that the saponification of the triacylglycerol in the passage resulted in four different fatty acid salts?

- A) The triacylglycerol molecule consisted of four different fatty acid units.
- B) Glycerol was transformed into a fatty acid salt under the reaction conditions.
- C) One of the fatty acid salts was unsaturated, and it completely isomerized under the reaction conditions.
- D) One of the fatty acid salts was unsaturated, and a small percentage isomerized under the reaction conditions.

**180.** A triacylglycerol can also be accurately described as a:

- A) triacid of glycerol.
- B) triether of glycerol.
- C) triester of glycerol.
- D) trihydroxy glycerol.

**181.** How much sodium hydroxide is needed to completely saponify a triacylglycerol?

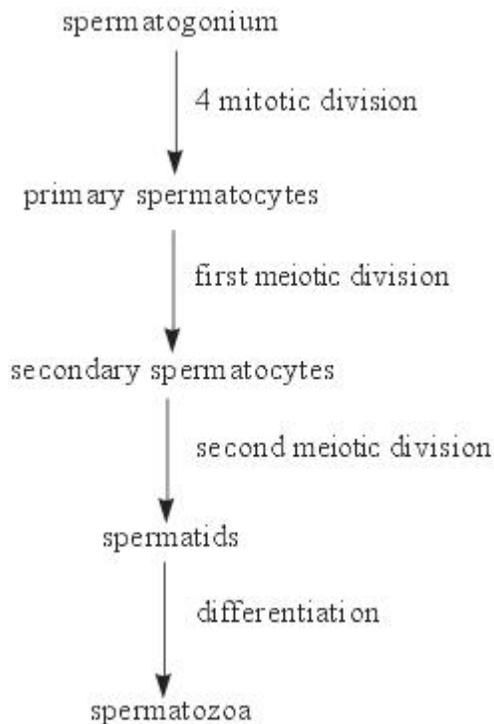
- A) A catalytic amount, because  $\text{OH}^-$  is continuously being regenerated during saponification
- B) One-third of an equivalent, because each  $\text{OH}^-$  ion reacts to form three fatty acid salts
- C) One equivalent, because each  $\text{OH}^-$  ion reacts to produce one molecule of glycerol
- D) Three equivalents, because one  $\text{OH}^-$  ion is required to saponify each of the three fatty acid groups

**182.** Which of the following statements most accurately describes the solubility properties of fatty acid salts?

- A) They are soluble in polar media only.
- B) They are soluble in nonpolar media only.
- C) They can partially dissolve in both polar and nonpolar media.
- D) They are completely insoluble in both polar and nonpolar media.

## Passage VIII

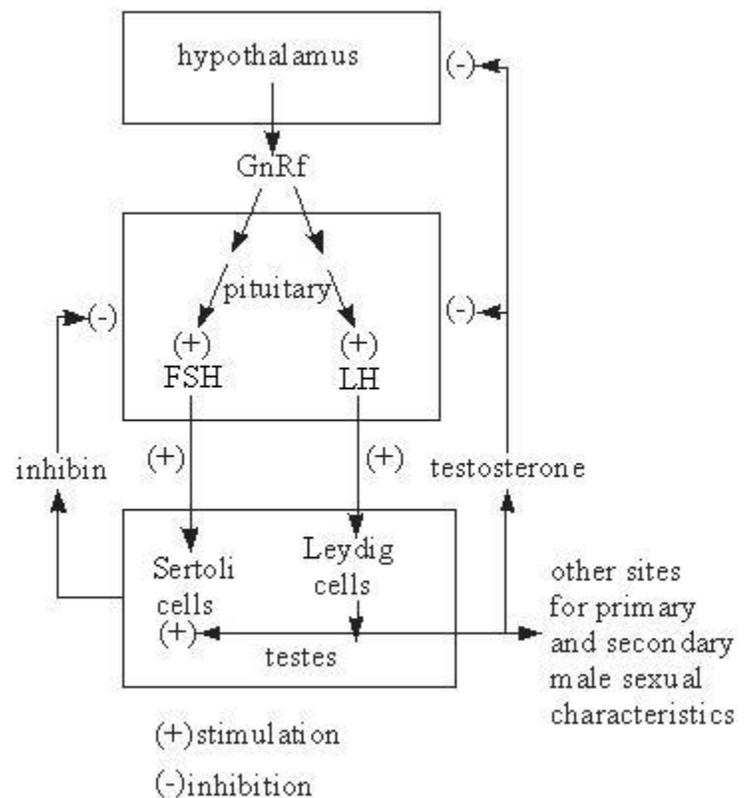
The testes have both an endocrine and an exocrine portion. The exocrine portion consists of the tightly coiled seminiferous tubules. Before puberty, the seminiferous tubules contain only spermatogonia and Sertoli cells. Beginning at puberty, each spermatogonium will undergo a series of mitotic and meiotic divisions, called spermatogenesis, that result in the production of mature spermatozoa (Figure 1). The Sertoli, or “nurse” cells, provide nutrients for the developing sperm. In addition, the Sertoli cell membranes form tight junctions, establishing a blood–testis barrier that protects developing sperm from potentially toxic bloodborne substances, such as proteins and polar compounds.



**Figure 1**

The endocrine portion of the testes consists of the Leydig cells located between the seminiferous tubules. The Leydig cells secrete testosterone, an important male hormone. Testosterone acts on the Sertoli cells to promote maturation of sperm; it also controls the development and maintenance of male sexual organs and secondary sexual characteristics.

Both the exocrine and endocrine functions of the testes are controlled by hormones from the hypothalamus and the pituitary (Figure 2). Gonadotropin-releasing factor (GnRF) from the hypothalamus stimulates the pituitary to synthesize and release follicle-stimulating hormone (FSH) and luteinizing hormone (LH). FSH acts directly on the Sertoli cells to promote and maintain spermatogenesis. LH acts on the Leydig cells to stimulate the production of testosterone. Testosterone in turn regulates testicular activity by inhibiting GnRF release from the hypothalamus and LH release from the pituitary. Inhibin, produced by the Sertoli cells, inhibits FSH release.



**Figure 2**

**183.** A male taking excess testosterone may become infertile because of reduced spermatogenesis. According to Figure 2, this could result directly from:

- A) an increase in inhibin concentration.
- B) a reduction in inhibin concentration.
- C) a reduction in FSH concentration.
- D) a reduction in LH concentration.

**184.** The cell type in the male reproductive system that is most analogous to the female ovum is the:

- A) spermatogonium.
- B) primary spermatocyte.
- C) spermatid.
- D) spermatozoon.

**185.** Some drugs used in cancer chemotherapy kill proliferating cancer cells by selectively inhibiting various stages of the life cycle. Which of the following normal reproductive processes is likely to be most affected by the use of chemotherapy?

- A) Sertoli cell function
- B) Testosterone production
- C) Spermatogenesis
- D) Inhibin production

**186.** Which of the following hormones is(are) directly required for spermatogenesis?

- I. Luteinizing hormone (LH)
- II. Follicle-stimulating hormone (FSH)
- III. Inhibin
- IV. Testosterone

- A) IV only
- B) I and IV only
- C) II and IV only
- D) I, II, and III only

**187.** On the basis of their function as “nurse” cells, which of the following organelles are most likely to be prominent in Sertoli cells?

- A) Golgi apparatus
- B) Lysosomes
- C) Mitochondria
- D) Cilia

**188.** Which of the following statements correctly describes the distinction between the exocrine and endocrine portions of the testis?

- A) The exocrine portion secretes only peptides; the endocrine portion secretes only steroids.
  - B) The exocrine portion releases its products into ducts; the endocrine portion releases its products into the blood.
  - C) The exocrine portion secretes only cellular elements; the endocrine portion secretes only chemical substances.
  - D) The exocrine portion is the target tissue for the products of the endocrine portion.
-

**These questions are not based on a descriptive passage and are independent of each other.**

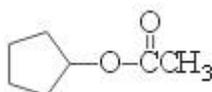
**189.** The pancreas produces which of the following substances for the digestive system?

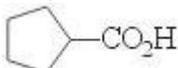
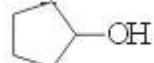
- A) Bile salts
- B) Emulsifier
- C) Gastric juices
- D) Proteolytic enzymes

**190.** Which of the following characteristics clearly marks fungi as eukaryotes?

- A) They have cell walls.
- B) They contain ribosomes.
- C) They contain mitochondria.
- D) They exhibit sexual reproduction.

**191.** If the ester shown below were hydrolyzed in acidic  $\text{H}_2^{18}\text{O}$ , which product would be expected to contain  $^{18}\text{O}$ ?



- A)  $\text{CH}_3\text{CO}_2\text{H}$
- B)  $\text{CH}_3\text{OH}$
- C) 
- D) 

**192.** From which germ layer(s) do the tissues of the heart and blood vessels differentiate?

- I. Ectoderm
- II. Mesoderm
- III. Endoderm

- A) II only
- B) III only
- C) I and II only
- D) I and III only

**193.** The most effective method for producing an increase in the total amount of water lost through the skin during a certain period would be:

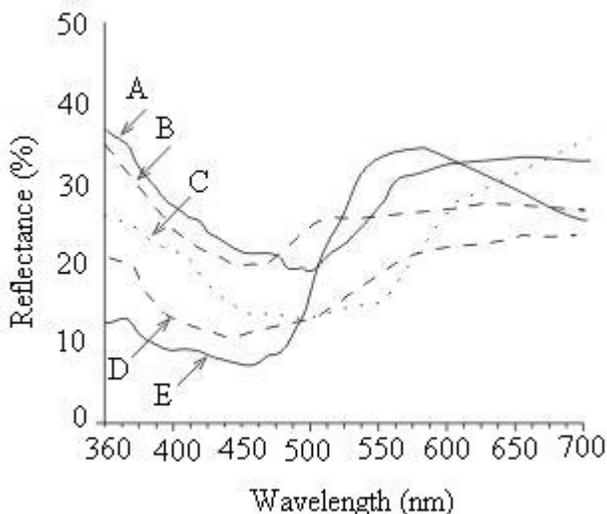
- A) inhibiting kidney function.
  - B) decreasing salt consumption.
  - C) increasing water consumption.
  - D) raising the environmental temperature.
-

## Passage IX

During a study on visual communication in five species of lizards in the genus *Anolis*, investigators discovered ultraviolet (UV) photoreceptors in the eyes of all five species. Additional studies were done to determine what role, if any, the ability to detect UV light plays in intraspecific communication.

The five species are closely related and live in Puerto Rico. Three species (A, B, and C) live in open unshaded fields, and the other two species (D and E) live in the understory of a closed canopy forest. Male lizards have a *dewlap*, a large fold of skin under the throat that they can fan out like a flag. Flashing the dewlap plays an important role in lizard communication such as territorial displays, warning signals, and courtship.

The investigators used specially enhanced cameras to measure the degree to which the dewlaps of the five species reflected UV light (defined as wavelengths around 360 nm). The dewlaps of two species exhibited high reflectance of UV light; two others showed low reflectance; and one species was intermediate. The investigators concluded that there was a relationship between dewlap UV reflectance and habitat. A summary of the data is shown in Figure 1.



**Figure 1** Reflectance spectra (percent reflectance compared to that from a magnesium carbonate white standard) from the dewlaps of five *Anolis* species

- 194.** To determine the significance of UV reflectance by the dewlap, it would be most useful to compare the behavior of:
- A) sighted and sightless lizards, in response to flashing of the dewlap.
  - B) lizards responding to flashing of normal dewlaps versus treated dewlaps that absorb UV.
  - C) the five lizard species, when they are placed together in the same habitat.
  - D) the five lizard species under illumination by red light only.
- 195.** If these lizards use UV light in communication, a mutation that eliminated UV photoreceptors would probably cause the LEAST disadvantage to:
- A) species A.
  - B) species B.
  - C) species D.
  - D) species E.
- 196.** If *Anolis* lizards have X-Y chromosomal sex determination, the locus of a gene for the UV reflectance pigment:
- A) must be on the X chromosome.
  - B) must be on the Y chromosome.
  - C) must be on an autosome.
  - D) could be on a sex chromosome or on an autosome.
- 197.** Two neighboring lizard populations would be considered separate species if:
- A) one population inhabited the forest and the other lived in a field.
  - B) one population had a UV-reflective dewlap and the other did not.
  - C) they did not communicate with each other.
  - D) they did not interbreed and produce fertile offspring.

**198.** Which of the following conclusions about dewlap reflectance is supported by information in the passage?

- A) Lizard habitat is determined by dewlap reflectance for each species.
- B) High dewlap reflectance is most important in brightly lit habitats.
- C) High dewlap reflectance is most important in dimly lit habitats.
- D) Dewlap reflectance is highest at the blue end of the visible spectrum.

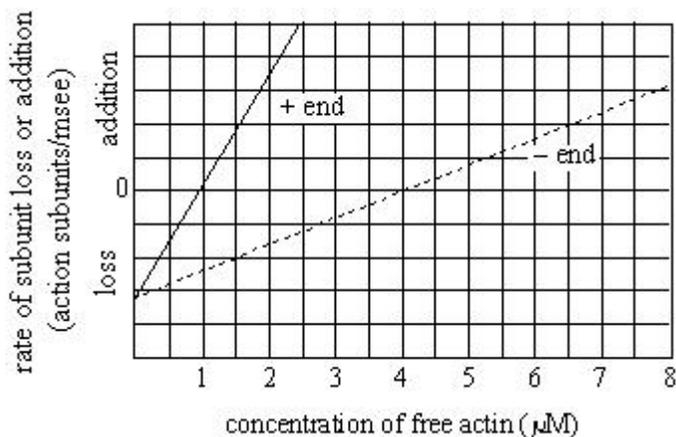
Dewlaps that reflect UV light would evolve by **199.** natural selection only if:

- A) individuals with UV-reflective dewlaps produced more offspring than did individuals without them.
  - B) individuals with UV-reflective dewlaps were better able to communicate than individuals without them.
  - C) individuals with UV-reflective dewlaps were less subject to predation than individuals without them.
  - D) individuals with UV-reflective dewlaps mated more frequently than did individuals without them.
-

## Passage X

*Microfilaments* were first identified as the actin-containing thin filaments of muscle cells. All eukaryotic cells are thought to contain microfilaments. Researchers suspect that microfilaments can generate force, even in the absence of myosin, by elongating and pushing against a structure such as the plasma membrane.

A microfilament has two ends, each of which can either gain or lose actin subunits. During microfilament growth, the *plus* (+) end of the microfilament grows faster than the *minus* (–) end. At a particular concentration of actin subunits, the rate of subunit addition (polymerization) is exactly balanced by the rate of subunit loss (depolymerization). This *critical concentration* is different for the + and – ends of the microfilament (Figure 1). When the rate of subunit addition at the + end equals the rate of subunit loss at the – end, the microfilament is undergoing a process called *treadmilling*.



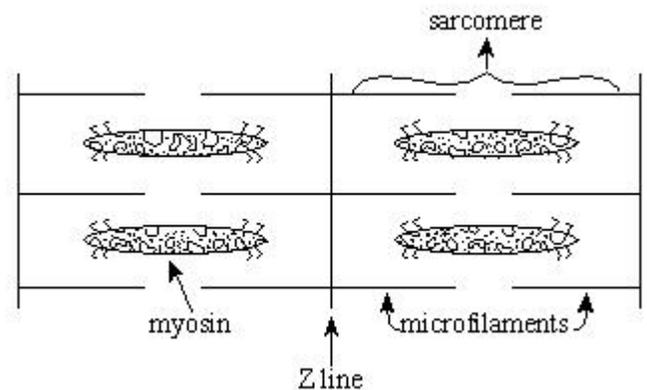
**Figure 1** Changes in the + and – ends of a microfilament as a function of actin concentration

Figure adapted from Alberts et al., *Molecular Biology of the Cell*. ©1989 by Garland Publishing Company.

Researchers believe that regulation of microfilament growth helps determine the shape of cells and the stability of their microfilaments. Within the cell, the addition or loss of subunits at each end of a microfilament can be controlled by *capping proteins*, which bind selectively to one of the ends. Some natural poisons also affect microfilament metabolism: the *cytochalasins* bind to the + end of a microfilament and prevent the addition of actin subunits to that end, and *phalloidin* blocks subunit loss from either end.

- 200.** At what concentration of free actin will the + end of the microfilament grow faster than the – end?
- A) Exactly at  $1 \mu\text{M}$   
 B) Only between  $1 \mu\text{M}$  and  $4 \mu\text{M}$   
 C) At any concentration greater than  $1 \mu\text{M}$   
 D) At any concentration

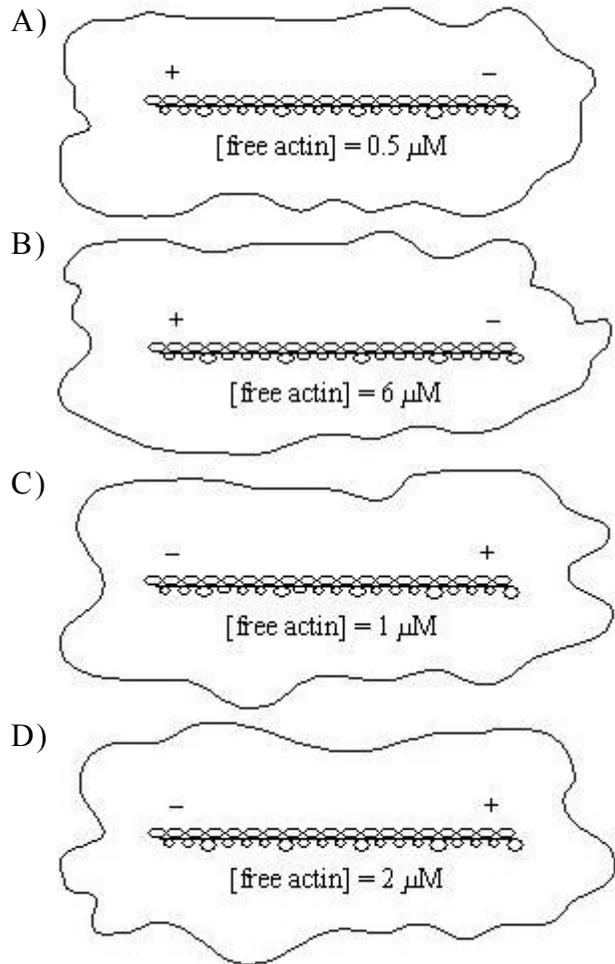
- 201.** Below is a diagram of a muscle sarcomere. Based on the passage, which statement best explains why the microfilament lengths do NOT change when the sarcomere shortens in a muscle contraction?



- A) The – ends of the microfilaments are capped by Z lines, and the actin subunit concentration is kept above  $1 \mu\text{M}$  in muscle cells.  
 B) The – ends of the microfilaments are capped by Z lines, and the + ends are capped by another protein.  
 C) The actin subunit concentration is kept above  $4 \mu\text{M}$  in muscle cells.  
 D) The – ends polymerize and the + ends depolymerize at the same rate.

- 202.** The theory of force generation proposed in the passage is best supported by which of the following observations about *Amoeba* locomotion?
- A) Amoeboid movement stops upon exposure to cytochalasins.
  - B) Amoeboid movement cannot occur if mitosis is blocked.
  - C) Moving *Amoeba* cells produce more troponin than do stationary ones.
  - D) The rate of movement is inversely proportional to the viscosity of the medium in which the *Amoeba* moves.
- 203.** Based on Figure 1, at what free actin subunit concentration (or range of concentrations) will the microfilament treadmill?
- A)  $0.25 \mu\text{M}$
  - B)  $1.0 \mu\text{M}$
  - C)  $1.5 \mu\text{M}$
  - D) Any concentration between  $1.0 \mu\text{M}$  and  $4.0 \mu\text{M}$
- 204.** Based on Figure 1, at what free actin subunit concentration (or range of concentrations) will both the + and - ends of the microfilament experience a net loss of subunits?
- A) At any concentration below  $1 \mu\text{M}$
  - B) Exactly at  $1 \mu\text{M}$
  - C) At any concentration above  $1 \mu\text{M}$
  - D) Only between  $1 \mu\text{M}$  and  $4 \mu\text{M}$
- 205.** Which of the following observations supports the hypothesis that microfilaments are involved in the release of viral particles?
- A) Exocytosis of viral particles from an infected cell is proportional to the rate of microfilament polymerization.
  - B) Treatment with phalloidin does not prevent the exocytosis of virus particles from the infected cell.
  - C) No known virus carries genes coding for actin subunits.
  - D) Some viruses have capsules composed of myosin.

- 206.** Assuming that *Amoeba* uses microfilament-generated forces for locomotion, which of the *Amoebas* pictured below will move from left to right?

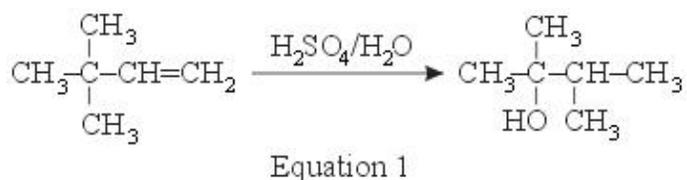


## Passage XI

An organic chemistry class prepared three different alcohols from the same alkene.

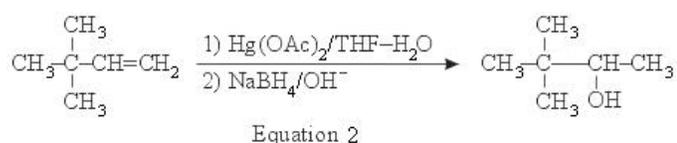
### Experiment 1

3,3-Dimethyl-1-butene was hydrated in the presence of an acid catalyst.



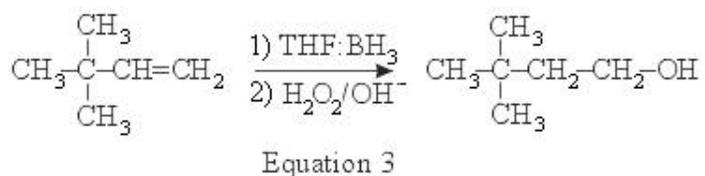
### Experiment 2

3,3-Dimethyl-1-butene was transformed into an alcohol through an oxymercuration–demercuration reaction.



### Experiment 3

An alcohol was produced from 3,3-dimethyl-1-butene via a hydroboration reaction.



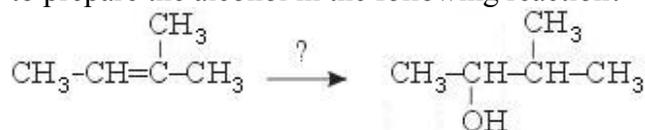
### Conclusion

Because three different alcohols were formed from the same starting material, the students deduced that each reaction must have a different mechanism.

207. In which of the experiments is a rearrangement of the carbon skeleton observed?

- A) 1 only
- B) 2 only
- C) 3 only
- D) 2 and 3 only

208. Which set of reagents or condition could be used to prepare the alcohol in the following reaction?



- A)  $\text{H}_2\text{SO}_4/\text{H}_2\text{O}$
- B)  $\text{Hg}(\text{OAc})_2/\text{THF}-\text{H}_2\text{O}; \text{NaBH}_4/\text{OH}^-$
- C)  $\text{THF}:\text{BH}_3; \text{H}_2\text{O}_2/\text{OH}^-$
- D) Heat

209. Alcohols have higher boiling points than hydrocarbons of comparable molecular weight. This is a result of:

- A) hydrogen bonding.
- B) van der Waals forces.
- C) covalent bonding.
- D) resonance.

210. Another way to prepare an alcohol is via a Grignard synthesis. Which of the following reactants can be used in a Grignard reaction to produce the same alcohol that was produced in Experiment 1?

- A)  $\begin{array}{c} \text{O} \\ || \\ \text{CH}_3\text{CCH}_3 \end{array} + \begin{array}{c} \text{CH}_3\text{CHMgBr} \\ | \\ \text{CH}_3 \end{array} \xrightarrow[2) \text{H}_3\text{O}^+]{1) \text{diethyl ether}}$
- B)  $\begin{array}{c} \text{CH}_3\text{CHCH}_3 \\ | \\ \text{OH} \end{array} + \begin{array}{c} \text{CH}_3\text{CHMgBr} \\ | \\ \text{CH}_3 \end{array} \xrightarrow[2) \text{H}_3\text{O}^+]{1) \text{diethyl ether}}$
- C)  $\begin{array}{c} \text{CH}_3 \\ | \\ \text{CH}_3\text{CCH}_3 \\ | \\ \text{OH} \end{array} + \text{CH}_2=\text{CHMgBr} \xrightarrow[2) \text{H}_3\text{O}^+]{1) \text{diethyl ether}}$
- D)  $\begin{array}{c} \text{O} \\ || \\ \text{CH}_3\text{CH} \end{array} + \begin{array}{c} \text{CH}_3 \\ | \\ \text{CH}_3\text{CCH}_3 \\ | \\ \text{MgBr} \end{array} \xrightarrow[2) \text{H}_3\text{O}^+]{1) \text{diethyl ether}}$

**These questions are not based on a descriptive passage and are independent of each other.**

- 211.** The discovery that the amount of thymine equals that of adenine and the amount of guanine equals that of cytosine in a given cell provides supporting evidence that:
- A) the Watson and Crick model of DNA is correct.
  - B) DNA is the genetic material.
  - C) the genetic code is universal.
  - D) the code for one amino acid must be a triplet of bases.
- 212.** Consider an organism that has three pairs of chromosomes, AaBbCc, in its diploid cells. How many genotypically different kinds of haploid cells can it produce?
- A) 4
  - B) 8
  - C) 16
  - D) 32
- 213.** What is the net volume of fresh air that enters the alveoli each minute, assuming that the breathing rate is 10 breaths/min, the tidal volume is 800 mL/breath, and the nonalveolar respiratory system volume (dead space) is 150 mL?
- A) 65 mL
  - B) 95 mL
  - C) 6500 mL
  - D) 7850 mL

In mammals, which of the following events

**214.** occurs during *mitosis* but does NOT occur during *meiosis I*?

- A) Synapsis
- B) The splitting of centromeres
- C) The pairing of homologous chromosomes
- D) The breaking down of the nuclear membrane

**215.** In a particular species of plant, tall vine depends on a dominant gene (*T*), and a pink flower is the result of the heterozygous condition of the genes for red and white flowers (*Rr*). What fraction of the offspring from the cross of a tall, pink plant (heterozygous for height) with a short, pink plant would be expected to be pink AND tall?

- A) 3/4
- B) 1/2
- C) 3/8
- D) 1/4

**216.** During prokaryotic protein synthesis, translation begins as soon as the newly synthesized mRNA strand begins to extend from the DNA strand. This situation differs from that in eukaryotes, because eukaryotes:

- A) carry out translation without using ribosomes.
  - B) transcribe mRNA molecules without using DNA.
  - C) destroy most mRNA as soon as it is synthesized.
  - D) localize the processes of transcription and translation in the nucleus and cytoplasm, respectively.
-

**Physical Sciences**

- 1 (A) (B) (C) (D)
- 2 (A) (B) (C) (D)
- 3 (A) (B) (C) (D)
- 4 (A) (B) (C) (D)
- 5 (A) (B) (C) (D)
- 6 (A) (B) (C) (D)
- 7 (A) (B) (C) (D)
- 8 (A) (B) (C) (D)
- 9 (A) (B) (C) (D)
- 10 (A) (B) (C) (D)
- 11 (A) (B) (C) (D)
- 12 (A) (B) (C) (D)
- 13 (A) (B) (C) (D)
- 14 (A) (B) (C) (D)
- 15 (A) (B) (C) (D)
- 16 (A) (B) (C) (D)
- 17 (A) (B) (C) (D)
- 18 (A) (B) (C) (D)
- 19 (A) (B) (C) (D)
- 20 (A) (B) (C) (D)
- 21 (A) (B) (C) (D)
- 22 (A) (B) (C) (D)
- 23 (A) (B) (C) (D)
- 24 (A) (B) (C) (D)
- 25 (A) (B) (C) (D)
- 26 (A) (B) (C) (D)
- 27 (A) (B) (C) (D)
- 28 (A) (B) (C) (D)
- 29 (A) (B) (C) (D)
- 30 (A) (B) (C) (D)
- 31 (A) (B) (C) (D)
- 32 (A) (B) (C) (D)
- 33 (A) (B) (C) (D)
- 34 (A) (B) (C) (D)
- 35 (A) (B) (C) (D)
- 36 (A) (B) (C) (D)
- 37 (A) (B) (C) (D)
- 38 (A) (B) (C) (D)
- 39 (A) (B) (C) (D)
- 40 (A) (B) (C) (D)
- 41 (A) (B) (C) (D)
- 42 (A) (B) (C) (D)
- 43 (A) (B) (C) (D)
- 44 (A) (B) (C) (D)
- 45 (A) (B) (C) (D)
- 46 (A) (B) (C) (D)
- 47 (A) (B) (C) (D)
- 48 (A) (B) (C) (D)
- 49 (A) (B) (C) (D)
- 50 (A) (B) (C) (D)
- 51 (A) (B) (C) (D)
- 52 (A) (B) (C) (D)
- 53 (A) (B) (C) (D)
- 54 (A) (B) (C) (D)
- 55 (A) (B) (C) (D)

- 56 (A) (B) (C) (D)
- 57 (A) (B) (C) (D)
- 58 (A) (B) (C) (D)
- 59 (A) (B) (C) (D)
- 60 (A) (B) (C) (D)
- 61 (A) (B) (C) (D)
- 62 (A) (B) (C) (D)
- 63 (A) (B) (C) (D)
- 64 (A) (B) (C) (D)
- 65 (A) (B) (C) (D)
- 66 (A) (B) (C) (D)
- 67 (A) (B) (C) (D)
- 68 (A) (B) (C) (D)
- 69 (A) (B) (C) (D)
- 70 (A) (B) (C) (D)
- 71 (A) (B) (C) (D)
- 72 (A) (B) (C) (D)
- 73 (A) (B) (C) (D)
- 74 (A) (B) (C) (D)
- 75 (A) (B) (C) (D)
- 76 (A) (B) (C) (D)
- 77 (A) (B) (C) (D)

**Verbal Reasoning**

- 78 (A) (B) (C) (D)
- 79 (A) (B) (C) (D)
- 80 (A) (B) (C) (D)
- 81 (A) (B) (C) (D)
- 82 (A) (B) (C) (D)
- 83 (A) (B) (C) (D)
- 84 (A) (B) (C) (D)
- 85 (A) (B) (C) (D)
- 86 (A) (B) (C) (D)
- 87 (A) (B) (C) (D)
- 88 (A) (B) (C) (D)
- 89 (A) (B) (C) (D)
- 90 (A) (B) (C) (D)
- 91 (A) (B) (C) (D)
- 92 (A) (B) (C) (D)
- 93 (A) (B) (C) (D)
- 94 (A) (B) (C) (D)
- 95 (A) (B) (C) (D)
- 96 (A) (B) (C) (D)
- 97 (A) (B) (C) (D)
- 98 (A) (B) (C) (D)
- 99 (A) (B) (C) (D)
- 100 (A) (B) (C) (D)
- 101 (A) (B) (C) (D)
- 102 (A) (B) (C) (D)
- 103 (A) (B) (C) (D)
- 104 (A) (B) (C) (D)
- 105 (A) (B) (C) (D)
- 106 (A) (B) (C) (D)
- 107 (A) (B) (C) (D)
- 108 (A) (B) (C) (D)
- 109 (A) (B) (C) (D)

- 110 (A) (B) (C) (D)
- 111 (A) (B) (C) (D)
- 112 (A) (B) (C) (D)
- 113 (A) (B) (C) (D)
- 114 (A) (B) (C) (D)
- 115 (A) (B) (C) (D)
- 116 (A) (B) (C) (D)
- 117 (A) (B) (C) (D)
- 118 (A) (B) (C) (D)
- 119 (A) (B) (C) (D)
- 120 (A) (B) (C) (D)
- 121 (A) (B) (C) (D)
- 122 (A) (B) (C) (D)
- 123 (A) (B) (C) (D)
- 124 (A) (B) (C) (D)
- 125 (A) (B) (C) (D)
- 126 (A) (B) (C) (D)
- 127 (A) (B) (C) (D)
- 128 (A) (B) (C) (D)
- 129 (A) (B) (C) (D)
- 130 (A) (B) (C) (D)
- 131 (A) (B) (C) (D)
- 132 (A) (B) (C) (D)
- 133 (A) (B) (C) (D)
- 134 (A) (B) (C) (D)
- 135 (A) (B) (C) (D)
- 136 (A) (B) (C) (D)
- 137 (A) (B) (C) (D)

**Writing Sample**

- 138
- 139

**Biological Sciences**

- 140 (A) (B) (C) (D)
- 141 (A) (B) (C) (D)
- 142 (A) (B) (C) (D)
- 143 (A) (B) (C) (D)
- 144 (A) (B) (C) (D)
- 145 (A) (B) (C) (D)
- 146 (A) (B) (C) (D)
- 147 (A) (B) (C) (D)
- 148 (A) (B) (C) (D)
- 149 (A) (B) (C) (D)
- 150 (A) (B) (C) (D)
- 151 (A) (B) (C) (D)
- 152 (A) (B) (C) (D)
- 153 (A) (B) (C) (D)
- 154 (A) (B) (C) (D)
- 155 (A) (B) (C) (D)
- 156 (A) (B) (C) (D)
- 157 (A) (B) (C) (D)
- 158 (A) (B) (C) (D)
- 159 (A) (B) (C) (D)
- 160 (A) (B) (C) (D)
- 161 (A) (B) (C) (D)

- 162 (A) (B) (C) (D)
- 163 (A) (B) (C) (D)
- 164 (A) (B) (C) (D)
- 165 (A) (B) (C) (D)
- 166 (A) (B) (C) (D)
- 167 (A) (B) (C) (D)
- 168 (A) (B) (C) (D)
- 169 (A) (B) (C) (D)
- 170 (A) (B) (C) (D)
- 171 (A) (B) (C) (D)
- 172 (A) (B) (C) (D)
- 173 (A) (B) (C) (D)
- 174 (A) (B) (C) (D)
- 175 (A) (B) (C) (D)
- 176 (A) (B) (C) (D)
- 177 (A) (B) (C) (D)
- 178 (A) (B) (C) (D)
- 179 (A) (B) (C) (D)
- 180 (A) (B) (C) (D)
- 181 (A) (B) (C) (D)
- 182 (A) (B) (C) (D)
- 183 (A) (B) (C) (D)
- 184 (A) (B) (C) (D)
- 185 (A) (B) (C) (D)
- 186 (A) (B) (C) (D)
- 187 (A) (B) (C) (D)
- 188 (A) (B) (C) (D)
- 189 (A) (B) (C) (D)
- 190 (A) (B) (C) (D)
- 191 (A) (B) (C) (D)
- 192 (A) (B) (C) (D)
- 193 (A) (B) (C) (D)
- 194 (A) (B) (C) (D)
- 195 (A) (B) (C) (D)
- 196 (A) (B) (C) (D)
- 197 (A) (B) (C) (D)
- 198 (A) (B) (C) (D)
- 199 (A) (B) (C) (D)
- 200 (A) (B) (C) (D)
- 201 (A) (B) (C) (D)
- 202 (A) (B) (C) (D)
- 203 (A) (B) (C) (D)
- 204 (A) (B) (C) (D)
- 205 (A) (B) (C) (D)
- 206 (A) (B) (C) (D)
- 207 (A) (B) (C) (D)
- 208 (A) (B) (C) (D)
- 209 (A) (B) (C) (D)
- 210 (A) (B) (C) (D)
- 211 (A) (B) (C) (D)
- 212 (A) (B) (C) (D)
- 213 (A) (B) (C) (D)
- 214 (A) (B) (C) (D)
- 215 (A) (B) (C) (D)
- 216 (A) (B) (C) (D)