

4



4

SCIENCE REASONING TEST

35 Minutes—40 Questions

DIRECTIONS: This test includes seven passages, each followed by several questions. Read the passage and choose the best answer to each question. After you have selected your answer, fill in the corresponding bubble on your answer sheet. You should refer to the passages as often as necessary when answering the questions. You may NOT use a calculator on this test.

PASSAGE I

Some students performed three studies to measure the average speed on a flat surface of a remote-controlled car with different types of wheels. Each study was conducted indoors in a temperature-controlled room. A straight track was constructed and measured to be 75 feet long. The car's travel time was measured from start to finish with a stopwatch. The temperature in the room was kept constant at 20° F and the surface was returned to its original condition after each trial. No modifications were made to the car aside from changing the wheels, and the car's batteries were fully charged before each trial.

Study 1

The students fitted the car with hard rubber wheels, which had deep treads, and placed it on the surface. One student started the car as another student simultaneously started the stopwatch. The student stopped the stopwatch as the car crossed the 75-foot mark. The students calculated the results of three separate trials and averaged the results (see Table 1).

Trial	Time (s)	Speed (ft/s)
1	22.8	3.28
2	23.2	3.23
3	22.5	3.33
Average:	22.8	3.28

Study 2

The students repeated the procedure used in Study 1, except they fitted the car with soft rubber wheels, which were smooth and lacked treads. The results are shown in Table 2.

Trial	Time (s)	Speed (ft/s)
1	57	1.31
2	56.4	1.33
3	56.7	1.32
Average:	56.7	1.32

Study 3

The students repeated the procedure used in Study 1, except they fitted the car with hard rubber wheels, which had studs imbedded into them instead of treads. The results are shown in Table 3.

Trial	Time (s)	Speed (ft/s)
1	11.3	6.64
2	11.6	6.47
3	12.1	6.20
Average:	11.7	6.44

- The fastest times resulted from using which wheels?
 - The speeds remained constant.
 - Hard rubber wheels with studs imbedded in them.
 - Soft rubber wheels with no treads.
 - Hard rubber wheels with deep treads.

GO ON TO THE NEXT PAGE.

4



4

2. According to Study 1, the average speed for all three trials was:
- F. greater than the speed measured in Trial 3.
 - G. less than the speed measured in Trial 1.
 - H. greater than the speed measured in Trial 2.
 - J. equal to the speed measured in Trial 2.
3. Which of the following statements is best supported by the results of all three studies?
- A. The average speed of a car with deeply treaded hard rubber wheels is approximately $\frac{1}{2}$ the average speed of car with soft rubber wheels.
 - B. The average speed of a car with studded, hard rubber wheels is approximately $\frac{1}{2}$ the average speed of car with deeply treaded hard rubber wheels.
 - C. The average speed of a car with soft rubber wheels lacking treads is approximately twice the average speed of car with deeply treaded hard rubber wheels.
 - D. The average speed of a car with studded, hard rubber wheels is approximately twice the average speed of car with deeply treaded hard rubber wheels.
4. Based on the passage, the higher average speeds were probably the result of:
- F. greater friction.
 - G. temperature variations.
 - H. too much sunlight.
 - J. statistical error.
5. During which of the following was the travel time of the car the slowest?
- A. Study 2, Trial 1
 - B. Study 2, Trial 2
 - C. Study 3, Trial 1
 - D. Study 1, Trial 2



PASSAGE II

The ninth planet of our solar system, Pluto, was discovered in 1930. It is the smallest planet in the solar system, with a surface area more than 300 times smaller than Earth's. Recently, Pluto's categorization as a planet has been debated. Two scientists discuss whether Pluto is a planet or another celestial object.

Scientist 1

Pluto is most certainly a planet. Some astronomers have suggested that Pluto be stripped of its planetary status, arguing that it is more accurately categorized as an asteroid or comet. However, with a 1,413 mile diameter, Pluto is almost 1,000 times bigger than an average comet, and it does not have a tail of dust and gas as comets do. A planet can be described as a non-moon, sun-orbiting object that does not generate nuclear fusion and is large enough to be pulled into a spherical shape by its own gravity. Strictly by definition alone, Pluto is a planet. Pluto is clearly not a moon, as it does not orbit another planet. Although Pluto's orbital path is irregular as compared with the other planets of the solar system, it undisputedly orbits the sun. Pluto does not generate heat by nuclear fission, distinguishing it from a star. It is large enough to be pulled into a spherical shape by its own gravitational force, distinguishing it from either a comet or an asteroid.

Scientist 2

There are many facts about Pluto suggesting that it is actually not a planet but a member of the Kuiper Belt, a group of sizable comets that orbit the sun beyond Neptune. First, Pluto is composed of icy material, as are the comets in the Kuiper Belt, while the other planets of the solar system fall into one of two categories: rocky or gaseous. The four inner planets, Mercury, Venus, Earth, and Mars are rocky planets; Jupiter, Saturn, Uranus, and Neptune are gaseous. Pluto is neither rocky nor gaseous but has an icy composition. In addition, Pluto is much too small to be a planet. It is less than half the diameter of the next smallest planet, Mercury. The Earth's moon is even larger than Pluto. Finally, the eccentricity of Pluto's orbit indicates that it is not a planet. Pluto is generally considered the ninth planet, but for twenty years of its 249 year orbit, it is actually closer to the sun than is Neptune, making it the eighth planet during that period of time. This irregular orbit is shared by over seventy Kuiper Belt comets.

6. Which of the following phrases best describes the major point of difference between the two scientists' viewpoints?
- F. The actual location of Pluto in the solar system.
 - G. The length of Pluto's orbit.
 - H. The shape of Pluto.
 - J. The classification of Pluto as a planet.
7. According to Scientist 2's viewpoint, compared to other planets of the solar system, Pluto's surface is:
- A. less icy.
 - B. more icy.
 - C. more gaseous.
 - D. more rocky.
8. Scientist 1's viewpoint indicates that Pluto differs from asteroids and comets in all of the following ways EXCEPT:
- F. Pluto can generate heat through nuclear fission.
 - G. Pluto is pulled into a spherical shape by its own gravitational force.
 - H. Asteroids and comets have a tail of gas and dust particles.
 - J. Asteroids and comets are much smaller than Pluto.
9. The polar ice caps on Pluto's surface melt one time during every 249-year orbit, exposing Pluto's truly rocky surface, which is similar to that of Mars. Based on the information provided, this finding, if true, would most likely weaken the position(s) of:
- A. Scientist 1 only.
 - B. Scientist 2 only.
 - C. both Scientist 1 and Scientist 2.
 - D. neither Scientist 1 nor Scientist 2.
10. With which of the following statements would both scientists most likely agree?
- F. The size of Pluto indicates that it could actually be a satellite of another planet.
 - G. Pluto should be classified as neither a planet nor a comet; a new category is indicated.
 - H. The surface composition of Pluto is irrelevant and should not be considered in its classification.
 - J. Pluto's erratic orbit differentiates it from all other planets in the solar system.
11. Scientist 1's viewpoint would be weakened by which of the following observations, if true?
- A. Scientists have recently discovered a Kuiper Belt comet with a radius of almost 1,500 miles.
 - B. Pluto only has one moon, Charon, which is half the size of Pluto.
 - C. Planets can be distinguished from comets by the lack of gas and dust particles in the wake of their orbits.
 - D. Comets and asteroids are capable of generating nuclear fission.
12. Which of the following statements best describes how Scientist 2 likens Pluto to a Kuiper Belt comet?
- F. Neither Pluto nor Kuiper Belt comets have identifiable atmospheres.
 - G. Neither Pluto nor Kuiper Belt comets are trailed by a cloud of gases and dust.
 - H. Both Pluto and Kuiper Belt comets have similar eccentric orbital patterns.
 - J. Both Pluto and Kuiper Belt comets are roughly half the size of the next smallest planet, Mercury.

4



4

PASSAGE III

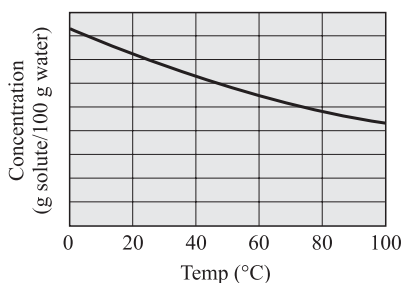
A *solute* is any substance that is dissolved in another substance, which is called the *solvent*.

A student tested the *solubility* (a measure of how much solute will dissolve into the solvent) of six different substances. The solubility of a substance at a given temperature is defined as the concentration of the dissolved solute that is in equilibrium with the solvent.

Table 1 represents the concentration of dissolved substances in 100 grams of water at various temperatures. The concentrations are expressed in grams of solute per 100 grams of water.

Temp (°C)	Concentration of solute (g/100 g H ₂ O)					
	KCl	NaNO ₃	HCl	NH ₄ Cl	NaCl	NH ₃
0	28	72	83	29	37	90
20	33	86	72	37	37	55
40	39	105	63	46	38	36
60	45	125	55	55	38	23
80	51	145	48	66	39	14
100	57	165	43	77	40	8

13. According to Table 1, the concentrations of which of the following substances varies the least with temperature?
- HCl
 - NH₃
 - NaCl
 - KCl
14. The graph below best represents the relationship between concentration and temperature for which of the following substances?



- HCl
- NaNO₃
- NaCl
- KCl

15. The data shown in Table 1 support the conclusion that, for a given substance, as the temperature of the water increases, the amount of solute that can be dissolved:
- increases only.
 - decreases only.
 - varies, but there is a trend depending on the substance.
 - varies, but with no particular trend.

16. According to Table 1, HCl would most likely have which of the following concentrations at 70°C?
- 25.5 g/100g H₂O
 - 37.0 g/100g H₂O
 - 48.5 g/100g H₂O
 - 51.5 g/100g H₂O

17. A scientist wants to dissolve at least 50 grams of NH₄Cl in 100 g of water in order for the solution to be the proper concentration for use in an experiment. A reasonable minimum temperature for the solution would be:
- 25°C
 - 30°C
 - 35°C
 - 50°C

4



4

PASSAGE IV

Salt pans are unusual geologic formations found in deserts. They are formed in *endorheic basins*, which are lowland areas where water collects but has no outflow. Any rain that falls or any water that is collected in an *endorheic basin* remains there permanently, except for what is lost through evaporation. This type of closed system often leads to a high concentration of salt and other minerals.

Study 1

Four different salt pans around the world were studied. The volumes of mineral deposits were estimated from the surface areas of the salt pans and the average thickness of the deposits. The ages of the salt pans were also estimated based on the mineral volume. The estimates are shown in Table 1.

Salt pan	Estimated mineral volume (km ³)	Estimated age (million years)
A	2,000,000	4.5
B	4,500,000	5.7
C	5,700,000	10.8
D	12,150,000	21.0

Study 2

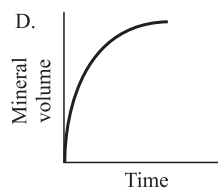
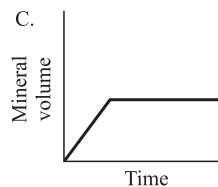
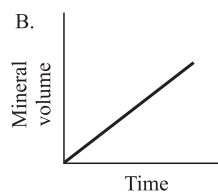
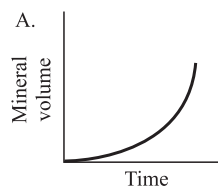
The same four salt pans were excavated for fossils. Fossil remnants of extinct plant species were found within each of the salt pans. The ages of the fossils found were similar to the ages of the salt pans (See Table 2). Scientists hypothesize that flooding of each salt pan may have led to the extinction of the plant species.

Salt pan	Type of fossils found	Estimated age of fossils (million years)
A	Plant species <i>q</i>	4.4
B	Plant species <i>r</i>	5.5
C	Plant species <i>s</i>	10.2
D	Plant species <i>t</i>	19.9

18. Which of the following statements is best supported by information in the passage?

- F. Water that has collected in *endorheic basins* is at least 21.0 million years old.
- G. The age of fossilized plant species cannot be precisely estimated.
- H. More water has collected in and evaporated from older salt pans.
- J. Any *endorheic basin* that is less than 2.0 million years old contains no fossils.

19. Which one of the following graphs best represents the relationship between the mineral volume and the age of the salt pans, according to Study 1?



4



4

20. Is the conclusion that Salt pan A contains more extinct plant fossils than does Salt pan D supported by information in the passage?
- F. Yes, because Salt pan A is younger than Salt pan D.
 - G. Yes, because the passage suggests that it is easier for plants to grow in areas with a lower mineral volume.
 - H. No, because Salt pan D contains a different type of fossilized plant.
 - J. No, because the passage does not include data regarding the quantity of plant fossils found in the salt pans.
21. From the results of Table 1, you could conclude that a salt pan formed more than 21 million years ago would have a mineral value:
- A. between 5,700,000 km³ and 12,150,000 km³.
 - B. equal to approximately $\frac{1}{2}$ the mineral volume of Salt pan B.
 - C. greater than 12,150,000 km³.
 - D. less than 2,000,000 km³.
22. A fossilized plant approximately 9.7 million years old was recently discovered in a salt pan in North America. It was most likely found in a salt pan similar to:
- F. Salt pan A.
 - G. Salt pan B.
 - H. Salt pan C.
 - J. Salt pan D.

4



4

PASSAGE V

Petroleum, or crude oil, is refined by separating it into different by-products. This process is called *fractional distillation*, whereby the crude oil is heated and each different product is distilled, or drawn off, at different stages. Each product is distilled at certain temperature ranges and collected in separate receivers. Petroleum refining is carried out in a boiler and a fractionating tower. The crude oil is super-heated in the boiler to about 600°C , which vaporizes the crude oil. The vapors then rise in the tower to certain levels where they cool and condense, according to their chemical structure. When the vapor reaches a height in the tower where the temperature in the column is equal to the boiling point of the substance, the vapor turns into liquid (condenses), collects in troughs, and flows into various tanks for storage, as shown in Figure 1. Table 1 below summarizes the characteristics of the by-products obtained from the fractional distillation of petroleum.

Petroleum by-product	Condensation temperature ($^{\circ}\text{C}$)
Petroleum gas	20–40
Gasoline	40–70
Kerosene	100–120
Gas oil	120–200
Lubricating oil stocks	200–300
Residue	600

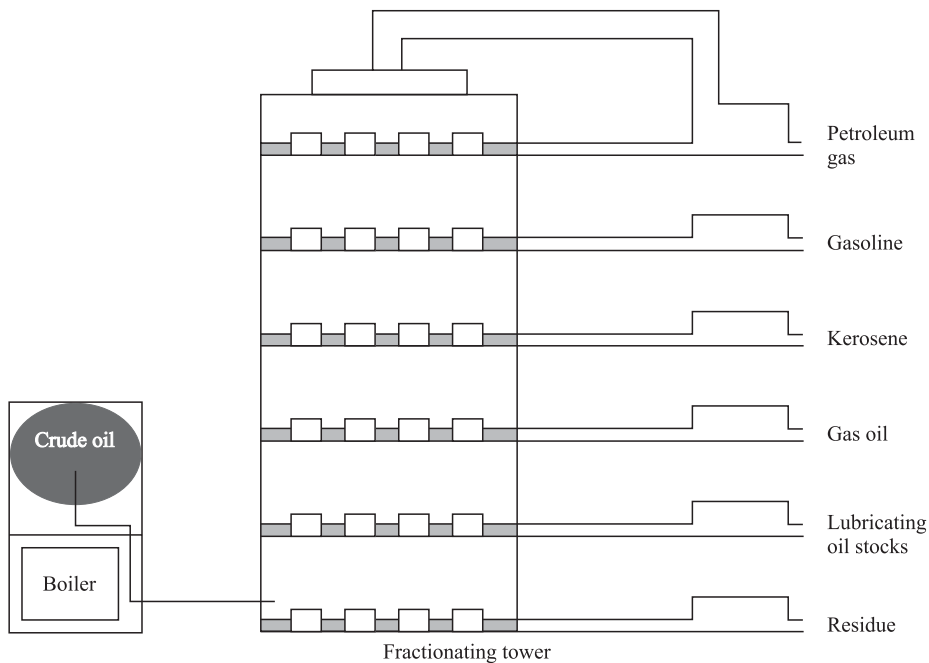


Figure 1

23. According to the passage, the temperature at which gasoline condenses is most likely:
- less than 0°C .
 - less than 40°C .
 - greater than 20°C .
 - greater than 70°C .
24. According to the passage, which by-product formed in the fractionating tower condenses first?
- Petroleum gas
 - Kerosene
 - Gas oil
 - Residue

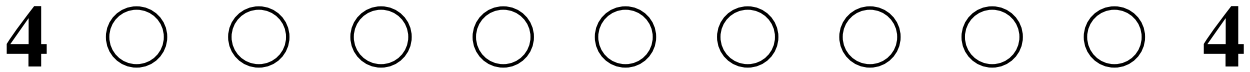
GO ON TO THE NEXT PAGE.

4



4

25. According to Figure 1, fractional distillation uses which of the following as a raw material?
- A. Gasoline
 - B. Residue
 - C. Crude oil
 - D. Gas oil
26. Given that naphtha, another by-product of petroleum distillation, has a condensation point of approximately 90°C , between which two petroleum by-products would this substance be found in a fractionating tower?
- F. Gasoline and kerosene
 - G. Lubricating oil stocks and gas oil
 - H. Kerosene and gas oil
 - J. Residue and lubricating oil stocks
27. According to the passage, at what temperature is most of the crude oil vaporized?
- A. 600°C
 - B. 300°C
 - C. 100°C
 - D. 20°C
28. According to the passage, as the vapor rises in the fractionating tower:
- F. the condensation temperature increases only.
 - G. the condensation temperature decreases only.
 - H. the condensation temperature increases quickly, then slowly decreases.
 - J. the condensation temperature remains stable at 600°C .



PASSAGE VI

Scientists theorize that the release of X-rays by distant stars and the amount of distortion or “bending” the X-rays endure as they travel out of their solar system can help indicate the presence of planets orbiting these stars. The distortion of the X-rays would be caused by the gravitational pull exerted by the planets. Specifically, high ‘bending’ in these rays would indicate the presence of large planets, while a low level of bending would most likely signify the presence of smaller planets.

In addition to determining whether or not there are planets circling a distant star, the amount of X-ray distortion can determine the planets’ orbital pattern. A circular orbit produces increasing or decreasing distortions of the same level. For instance, if a star’s X-rays are bent 1 meter the first day, 2 meters the fourth day, 4 meters the seventh day, and so on, it indicates a circular orbit. See Figure 1. If however, the pattern of bending is random, as in a bending of 5 meters the first day, 3 meters the second day, 0 meters the third day, and 7 meters the fourth day, then the planet’s orbit is elliptical. See Figure 2. Further, if the paths of the X-rays are not bent in any way, it is assumed that the star lacks any planets.

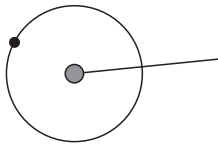


Figure 1 Circular orbit

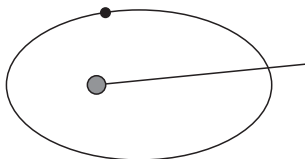


Figure 2 Elliptical orbit

Table 1 shows the amount of distortion of X-rays released by 4 different stars over a period of 10 days.

	X-ray distortion (m)			
	Day 1	Day 4	Day 7	Day 10
Star 1	1.00	1.75	2.50	3.25
Star 2	0.00	0.00	0.00	0.00
Star 3	8.00	4.00	2.00	1.00
Star 4	0.20	0.10	0.11	0.11

Note: Assume that there are no other objects that could affect the X-rays.

29. According to Table 1, which star most likely has no planets?
 - A. Star 1
 - B. Star 2
 - C. Star 3
 - D. Star 4

30. Based on the information in the passage, how many of the stars listed in Table 1 have at least one planet with a circular orbit?
 - F. 0
 - G. 2
 - H. 3
 - J. 4

31. Which of the following statements is best supported by information in the passage?
 - A. Star 3 is likely orbited by at least one large planet.
 - B. Star 4 has a circular orbit.
 - C. Star 1 has an elliptical orbit.
 - D. Star 2 is likely orbited by several small planets.

32. If X-ray distortion were observed for an additional three days, one could predict that the path of the X-rays produced by Star 1 on day 13 would be distorted by:
 - F. 0.75 meters.
 - G. 1.00 meter.
 - H. 3.75 meters.
 - J. 4.00 meters.

33. According to information in the passage, which of the following assumptions could be true?
 - A. X-rays are affected by certain physical forces.
 - B. X-rays are simply bits of energy and are, therefore, unaffected by physical forces.
 - C. Planets with elliptical orbits are more common than are planets with circular orbits.
 - D. The presence of planets orbiting a star can only be detected using X-ray distortion.

34. Based on information in the passage, which of the following stars most likely has at least one planet with an elliptical orbit?
 - F. Star 2 only
 - G. Star 4 only
 - H. Stars 1 and 3 only
 - J. Stars 1, 3, and 4 only

4



4

PASSAGE VII

Bacteria can be categorized by how they respond, as indicated by reproduction and growth, to certain temperatures. They are grouped into four categories—psychrophiles, psychrotrophs, mesophiles, and thermophiles—based on their growth response to certain temperatures. Minimal growth temperature is the lowest point at which the bacteria will reproduce. Optimum growth point is the temperature at which the bacteria reproduce most efficiently. Maximum growth point is the very highest temperature to which the bacteria will respond, beyond which the bacteria will not reproduce at all. Table 1 lists the types of bacteria as well as the growth points for each.

Table 2 represents a list of common bacteria and their growth points.

Table 1			
Growth points or ranges (°C)			
Classifications	Minimum	Optimum	Maximum
Psychrophile	below 0	10–15	below 20
Psychrotroph	0–5	15	30
Mesophile	5–25	18–45	30–50
Thermophile	25–45	50–60	60–90

Table 2			
Cardinal growth points (°C)			
Bacteria name	Minimum	Optimum	Maximum
<i>Anoxybacillus flavithermus</i>	30	60	72
<i>Bacillus flavothermus</i>	30	60	72
<i>Clostridium perfringens</i>	15	45	50
<i>Escherichia coli</i>	10	37	45
<i>Listeria monocytogenes</i>	1	34	45
<i>Micrococcus cryophilus</i>	0	15	30
<i>Staphylococcus aureus</i>	10	37	45
<i>Streptococcus pyogenes</i>	20	37	40
<i>Streptococcus pneumoniae</i>	25	37	42

35. The category of bacteria appearing the most frequently in Table 2 is:
- psychrophile.
 - psychrotroph.
 - mesophile.
 - thermophile.
36. The type of bacteria found in Table 2 that does not fit exactly into any of the categories listed in Table 1 is:
- Clostridium perfringens*.
 - Listeria monocytogenes*.
 - Micrococcus cryophilus*.
 - Streptococcus pneumoniae*.
37. Average human body temperature is 40°C. According to Table 2, which of the following bacteria would grow most successfully in the human body?
- Anoxybacillus flavithermus*.
 - Clostridium perfringens*.
 - Escherichia coli*.
 - Listeria monocytogenes*.
38. A new bacteria was discovered by scientists. It reproduces best at 55°C and does not show any new growth if exposed to temperatures above 65°C. This bacteria can most likely be categorized as a:
- psychrophile.
 - psychrotroph.
 - mesotroph.
 - thermophile.

GO ON TO THE NEXT PAGE.

4



4

39. Based on the information in Table 2, which bacteria has the smallest growth range?
- A. *Listeria monocytogenes*.
 - B. *Micrococcus cryophilus*.
 - C. *Streptococcus pneumoniae*.
 - D. *Streptococcus pyogenes*.
40. According to information provided in the passage, *Listeria monocytogenes* stop reproducing at what temperature?
- F. $>1^{\circ}\text{C}$, but $<10^{\circ}\text{C}$
 - G. $>10^{\circ}\text{C}$, but $<34^{\circ}\text{C}$
 - H. $>34^{\circ}\text{C}$, but $<45^{\circ}\text{C}$
 - J. $>45^{\circ}\text{C}$

**END OF THE SCIENCE REASONING TEST.
STOP! IF YOU HAVE TIME LEFT OVER, CHECK YOUR WORK ON THIS SECTION ONLY.**