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# The SAT®

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# Test Book

## IMPORTANT REMINDERS

**1**

A No. 2 pencil is required for the test.  
Do not use a mechanical pencil or pen.

**2**

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**Test begins on the next page.**

# Reading Test

65 MINUTES, 52 QUESTIONS

Turn to Section 1 of your answer sheet to answer the questions in this section.

## DIRECTIONS

Each passage or pair of passages below is followed by a number of questions. After reading each passage or pair, choose the best answer to each question based on what is stated or implied in the passage or passages and in any accompanying graphics (such as a table or graph).

### Questions 1-10 are based on the following passage.

This passage is adapted from Frances de Pontes Peebles, *The Air You Breathe*. ©2018 by Frances de Pontes Peebles. The narrator is a young woman joining Vinicius, a guitar player, and other musicians in Lapa, Brazil, in the 1930s.

The roda was a ritual. It was an event, not a show. What's the difference? A show's done for those watching. The roda was done for those of us playing and singing and composing. If you weren't part of the roda, you didn't exist. The roda was a conversation among musicians, into which you had to be invited. There were hundreds, maybe even thousands, of rodas in Lapa every night. But every samba roda had the same rules.

10 Newcomers were always treated with indifference. Even if you were the best guitar player, or cuíca player, or composer, or cavaquinho player, in the world, you had to be invited to join the circle. Don't even think about joining and fighting to set the

15 pace right away—newcomers only follow. The batucada—that glorious, improvised roda sound—was like a school of fish, sometimes floating serenely together, sometimes darting faster than you could keep up with, but you had to earn the right to lead that school. And the songs? Don't even think about playing a lighthearted marchinha—those were for once a year, for Carnival, for outsiders. Samba in the roda had mirth but it wasn't a party; it was a

lament. When you play samba in the roda, you laugh at your own misery. You and your loneliness hold hands and traipse through the music, in awe of how pathetic and glorious you both are.

Even after the record deals and radio play and endorsement contracts; even after samba was declared Brazil's national music, the roda remained a sacred space. There, it was blasphemy to speak of a song's catchiness, or to call it a hit. In order to be a "true sambista" you were required to pretend that samba was not a product. Sure, individual songs could be recorded and sold, but samba itself could not be soiled by such mundane transactions. If you were true to your art, you did not seek success but stumbled upon it.

I was allowed into the roda's embrace each night, but not into the roda itself.

The boys pulled a chair behind Vinicius for me each night, and then shut me out of the circle. They played long instrumentals, making up songs as they went along. Occasionally they toyed around with the lyrics of a few traditional sambas that everyone already knew. Vinicius always send the leads, and his voice was clear and plain, as if he'd sat his listeners down for a frank talk.

One night, after a week of visiting Ciata's, I tapped my nails against the metal table in time to the boys' music. Another night, I clinked the tip of a bottle against my empty glass. On another night, I shook a box of matches. Each night I pulled my chair closer to the circle, then closer still. Until, one day, I wasn't sitting behind Vinicius anymore but beside him, ticking away the beat, moving in time with the

men around me. No one looked up from their instruments. The music did not stop, the boys did not complain. To mask my elation, I focused even  
60 harder on keeping the beat.

One night, we stayed so late at Ciata's that Lapa grew quiet. There were only four of us left outside: me, Vinicius, Tiny, and Kitchen. My backside ached from the wooden folding chair. My throat stung.  
65 Tiny snored in his chair. Vinicius strummed a tune on his guitar. In the early-morning quiet, the notes sounded crisp and startling. I closed my eyes. In my head, those notes formed words:

*I'm here, they said. Always by your side. I buy your  
70 food. I make your bed. I place the pillow under your head. But you don't notice. You don't care. You seem to think I'll always be there. What would happen, if I were to leave? No one notices the air they breathe.*

"What's wrong?" Vinicius asked. He stopped  
75 playing and placed a cool hand over mine. I opened my eyes.

"You don't like it?" he asked. "The tune's no good."

"No, it *is* good," I whispered, hoping Kitchen  
80 wouldn't hear. "It's just . . . I heard something in it," I shook my head, embarrassed. "It's nothing. Keep going."

"No," Vinicius said, quite stern. "Tell me what you hear."

85 I glanced at Tiny and Kitchen, then at my hands. Vinicius put down his guitar, stood, and loped to the bar, where he found a scrap of paper and a pencil.

"Put it here," he ordered.

Vinicius played the tune again and I wrote down  
90 the words I'd heard in his notes. The boys looked on. When I showed Vinicius the paper, he stuck out his bottom lip and bopped his head from one side to the other.

"It could be a chorus," Vinicius said. "*No one  
95 notices the air they breathe.* That's pretty good."

1

The discussion about the school of fish (lines 16-20) serves primarily to

- A) use sensory imagery to show how a certain musical style became widespread.
- B) make a comparison between different types of artistic expression.
- C) provide an analogy to explore the effect of a musical style on a culture.
- D) describe an auditory experience using an evocative visual image.

2

In line 6, the narrator refers to a "conversation" to emphasize the

- A) lively but exclusive interaction among the roda performers.
- B) extensive but respected customs shared by all rodas.
- C) complex but compelling rhythms of roda music.
- D) cheerful but limited banter between roda singers and the public.

3

Which choice best supports the idea that the songs played in samba rodas tend to evoke a particular feeling?

- A) Lines 11-13 ("Even . . . circle")
- B) Lines 14-15 ("Don't . . . follow")
- C) Lines 25-27 ("You . . . are")
- D) Lines 39-40 ("I was . . . itself")

4

As used in line 37, "true to" most nearly means

- A) dependable about.
- B) sincere about.
- C) accurate in.
- D) simple in.

5

Which claim about the narrator's attempt to join the roda can most reasonably be inferred from the passage?

- A) The narrator is tentatively allowed to participate in the roda but is then quickly dismissed as being too inexperienced.
- B) The narrator successfully joins the roda but never receives an explicit invitation to join.
- C) The narrator joins the roda but has to compromise some of her artistic values in order to be accepted by the musicians.
- D) The narrator impresses the musicians at the roda but fails to captivate the audience.

6

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 32-38 ("In order . . . upon it")
- B) Lines 41-44 ("The boys . . . along")
- C) Lines 54-59 ("Until . . . complain")
- D) Lines 89-93 ("Vinicius . . . other")

7

The main purpose of the seventh paragraph (lines 61-68) is to

- A) underscore a mood of determined ambition.
- B) suggest a sudden shift in attitude.
- C) establish a mood of weary intensity.
- D) emphasize a sense of increasing dread.

8

Which choice most closely captures the literal meaning of the figurative phrase "*No one notices the air they breathe*" in lines 73 and 94-95?

- A) No one regrets how easy it is to ignore the most precious aspects of life.
- B) No one respects the fact that other people also require care and attention.
- C) No one understands the true relationship between humans and nature.
- D) No one pays attention to things that are both essential and freely available.

9

The passage indicates that once the narrator becomes a part of the roda, Vinicius

- A) slightly offends her by excessively questioning the logic behind her musical decisions.
- B) clearly establishes her authority by telling the others to follow her instruction.
- C) openly indicates his respect for her as a musician by soliciting her opinions.
- D) resentfully acknowledges her ideas by begrudgingly accepting her input.

10

Based on Vinicius's reaction to the narrator's lyrics, it can most reasonably be inferred that he is willing to

- A) experiment with unfamiliar genres of music to better his work.
- B) transform his improvised music into a more fixed composition.
- C) use personal experience as inspiration to make his music more authentic and engaging.
- D) switch his focus going forward as a musician from singing to songwriting.

**Questions 11-21 are based on the following passage and supplementary material.**

This passage is adapted from Pascal Boyer, *Minds Make Societies: How Cognition Explains the World Humans Create*. ©2018 by Pascal Boyer.

Humans are so attached to forming groups that they seem to create group solidarity, and conflicts between groups, on the flimsiest of excuses. A salient  
Line aspect of groupishness is the contrast between the  
5 often tenuous link between members of the group, their actual connections, and strong motivations to defend the group and attack rival ones. History records many examples of this, like the famous Nika riots of 532 CE, in which supporters of rival chariot  
10 racing teams, the Blues and the Greens, attacked each other and then destroyed about half the city of Constantinople.

From such examples, social psychologists inferred that humans were, indeed, so spontaneously  
15 groupish that they would favor their group even if the group was entirely arbitrary, and even if groups were arbitrarily constructed by an experimenter. A spectacular demonstration of the phenomenon was Henri Tajfel's "minimal group" paradigm, where  
20 people were assigned to two distinct groups, A and B, or blue and red, or any other meaningless label, on the basis of clearly arbitrary criteria. People grouped together had nothing particular in common; in fact they did not interact during the experiment. They  
25 were just told that they had been assigned to group A or B, and which group each other participant belonged to. After a while, in an ostensibly unrelated task, they were asked to allocate various goods and tokens among all participants. The result, replicated  
30 many times, was that people invariably tended to favor members of their own group. The effect remains the same, whatever the value of the goods, the familiarity of the task, or the cultural background of the participants.

35 These results seem to demonstrate a strong, automatic motivation to benefit one's group, however spurious the group. That is precisely the

point, for psychologists, of making the groups minimal. Members of such groups have nothing in  
40 common except the label they have just been given. One can even randomize group assignment right in front of the participants and still get the effect. That is to say, one seems to favor members of one's own group in situations where there is no possible reason  
45 for doing so except that these individuals have just been described as belonging to the same category as oneself, which seems irrational.

But do the results really show indiscriminate groupishness? As social psychologists after Tajfel  
50 pointed out, so-called minimal groups are not actually that minimal. In the experimental paradigms, participants allocate goods or symbolic good points to all others, and (this is crucial) they expect to receive similar goods or symbolic good  
55 points from all others. So, in the context of the study, their own welfare or self-esteem depends on the fact that they will be favored by others. This sheds a different light on the apparent irrationality of the effect. It is not that people wrongly think of an  
60 arbitrary grouping as a real social group. Rather, as the psychologist Toshio Yamagishi pointed out, the mistake is for participants to assume that they are engaging in a social exchange interaction, in which people can reciprocate favors. Participants, knowing  
65 that they will allocate goods to others and receive goods allocated by these same others, intuitively (and wrongly, in this case) infer that they will receive more if they give more. As this reciprocation heuristic is constantly activated in real in-group  
70 situations, people spontaneously apply it to whatever in-group situation they experience. Empirical evidence confirms this. When participants allocate goods to others but do not receive goods from these same others, the in-group bias disappears.

**Table 1**

Subjects' Allocation of Money to Two Recipients in Tajfel's Minimal Group Experiment

| Information provided to subjects   | Recipients' relationship to subject                                   | Mean allocation score<br>(0 = allocated maximum to recipient 1;<br>13 = allocated maximum to recipient 2;<br>6.5 = allocated equally) |
|--|---|---|
| groups created based on a shared preference for one set of abstract paintings over another | recipient 1 is an in-group member, recipient 2 is an out-group member | 4.38  |
| group created randomly   | recipient 1 is an in-group member, recipient 2 is an out-group member | 5.92  |
| no groups created  | recipient 1 and recipient 2 are random individuals                    | 6.62  |

Adapted from Michael Billig and Henry Tajfel, "Social Categorization and Similarity in Intergroup Behaviour." ©1973 by John Wiley & Sons, Inc.

**Table 2**

Subjects' Allocation of Money to One In-Group Recipient and One Out-Group Recipient with and without Expectation of Reciprocation

| Allocation condition   | Mean amount in Japanese yen by which subjects' allocation to in-group recipients exceeded an even division of the money to be allocated to the two recipients |
|--|---|
| subjects allocate to recipients and receive allocations from recipients        | 33.44   |
| subjects allocate to recipients but do not receive allocations from recipients | 0.07  |

Source: Data from David Karp et al., "Raising the Minimum in the Minimal Group Paradigm." ©1993 by The Japanese Group Dynamics Association.

11

As used in line 4, "aspect" most nearly means

- A) appearance.
- B) feature.
- C) manner.
- D) prospect.



12

According to the passage, Tajfel's "minimal group" paradigm (line 19) reveals that

- A) the existence of in-group bias is more likely to arise in smaller groups than in larger ones.
- B) people require a basic sense of common purpose if they are to feel loyalty to a group.
- C) a sense of group identification emerges when people start to engage in the exchange of resources.
- D) in-group bias can occur even when the basis of the group's existence is apparently insignificant.

13

Which choice best suggests a way for studies such as Tajfel's to eliminate the possibility that participants would believe an underlying and significant reason for their group's formation exists?

- A) Lines 31-34 ("The effect . . . participants")
- B) Lines 37-39 ("That . . . minimal")
- C) Lines 39-40 ("Members . . . given")
- D) Lines 41-42 ("One . . . effect")

14

The question in lines 48-49 ("But do . . . groupishness") mainly serves to

- A) state the central research question in Tajfel's study.
- B) suggest uncertainty about an interpretation of Tajfel's findings.
- C) introduce a factor overlooked by most social psychologists.
- D) highlight a problem in social psychology that remains unexamined.

15

As used in line 62, "assume" most nearly means

- A) believe.
- B) pretend.
- C) undertake.
- D) guess.

16

Yamagishi's observations most strongly support which statement about social interactions?

- A) People think that the mere sense of belonging to a group is sufficient motivation for favoring their own group.
- B) People will treat others outside of their group more generously if they learn they have common interests.
- C) People believe that their prior experiences of group dynamics in other contexts will likely have relevance in new situations.
- D) People will act to benefit those in their group even if they will not be personally rewarded for doing so.

17

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 55-57 ("So, in . . . others")
- B) Lines 57-59 ("This . . . effect")
- C) Lines 60-64 ("Rather . . . favors")
- D) Lines 68-71 ("As this . . . experience")

18

According to table 1, what was the mean allocation score when groups were created randomly?

- A) 4.38
- B) 5.92
- C) 6.5
- D) 6.62

19

Taken together, tables 1 and 2 best support which statement?

- A) The effect of in-group favoritism disappears when either the possibility of group identification or the possibility of reciprocation is removed.
- B) The existence of group identity based on shared preferences is a stronger incentive for in-group favoritism than the expectation of reciprocation is.
- C) In-group favoritism becomes more pronounced as the value of the allocated resources that subjects receive from other participants increases.
- D) Subjects who receive no allocations from other participants show less in-group favoritism in groups created randomly than in groups based on shared preferences.

20

Table 1 provides additional information that can be used to answer which question that could not be answered based on the passage alone?

- A) Do people who have something in common with their group demonstrate stronger in-group bias than people in groups formed at random demonstrate?
- B) Do members of a group who interact directly show more in-group favoritism than members of a group who only interact indirectly show?
- C) Are the requirements of an allocation task more likely to prompt individuals to demonstrate in-group preferences than when no task is assigned?
- D) Are groups formed in an experimental context less likely to demonstrate in-group preferences than groups formed outside the context of an experiment are?

21

The data in table 2 best support which statement about the associated reciprocation study?

- A) Subjects allocated more resources when they used actual currency rather than points with no monetary value.
- B) Subjects divided their resources between in-group and out-group recipients in approximately even amounts when they did not receive allocations in return.
- C) Subjects who expected reciprocation from their group were more likely to engage in intergroup conflict than when subjects did not have those expectations.
- D) Subjects who were not assigned to a group allocated their resources more equally among all participants in the study.

**Questions 22-32 are based on the following passage and supplementary material.**

This passage is adapted from Xiaofeng Feng, "A Sustainable, Energy-Saving Way to Make the Key Ingredient in Fertilizers." ©2018 by The Conversation US, Inc.

Ammonia is a critical ingredient in agricultural fertilizers. With more than 145 million tonnes manufactured annually, only sulfuric acid outranks it as the world's most produced chemical.

Manufacturing this simple molecule, made from just four atoms—one nitrogen and three hydrogen—is, however, surprisingly difficult and one of the most energy-intensive manufacturing processes on the planet, consuming 3 to 5 percent of the world's annual natural gas production.

With a growing world population, escalating demand for food and energy and the looming perils of fossil fuel induced climate change, there is an urgent need to make ammonia synthesis more sustainable by using renewable energy sources such as solar or wind-generated electricity. In my lab at the University of Central Florida, we are developing an efficient catalyst to facilitate ammonia production using electricity.

Ammonia is currently produced through the Haber-Bosch process, which was developed by German chemists Fritz Haber and Carl Bosch in the early 20th century, and requires high temperature (350–550 degrees Celsius) and high pressure (2,200–5,100 pounds per square inch) to accelerate the naturally slow reaction. Their contributions to industrial scale ammonia manufacturing processes earned them both Nobel Prizes in chemistry in 1918 and 1931, respectively.

The Haber-Bosch process uses iron to speed up the chemical reaction that combines nitrogen gas from the air with hydrogen to produce ammonia. But scientists are pursuing a more efficient way to facilitate the reaction. We thought that an electrochemical method, which uses electrical energy to convert nitrogen gas and water to ammonia at room temperature, could be a promising approach. But the reaction was incredibly slow—and we needed an efficient catalyst to speed it up.

After reading through chemistry journals, we were inspired by a team at Stanford University who used a rare, silvery metal called palladium to accelerate their electrochemical conversion of carbon

dioxide. As far as we could tell, this catalyst had received little attention for the production of ammonia, as it was considered to favor the undesirable production of hydrogen.

Surprisingly, we discovered that palladium catalyst can enable ammonia production quickly and efficiently with minimal electrical input, making it energetically more efficient than previous approaches, as documented in our work published in *Nature Communications*.

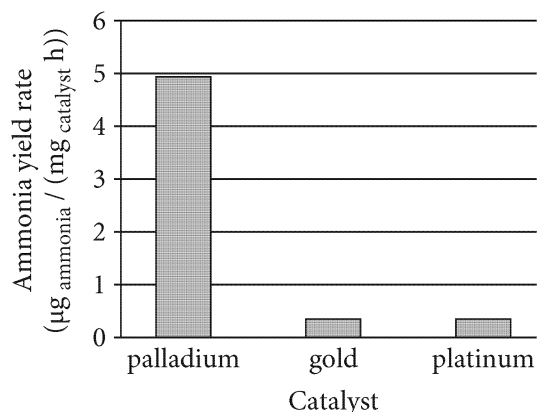
Our computational work suggests that palladium is a great catalyst because it speeds up the chemical reaction in a different way than conventional materials. Basically, palladium is unique in absorbing hydrogen atoms from water and forming an intermediate called palladium hydride, from which hydrogen atoms can hop to nitrogen molecules to produce ammonia. Such a pathway requires less energy than directly adding hydrogen from water to nitrogen molecules.

As a fundamental study and a proof of concept, we demonstrated the approach in a glass cell filled with a water solution at room temperature, and then ran an electrical current through carbon electrodes that were loaded with nano-sized palladium particles.

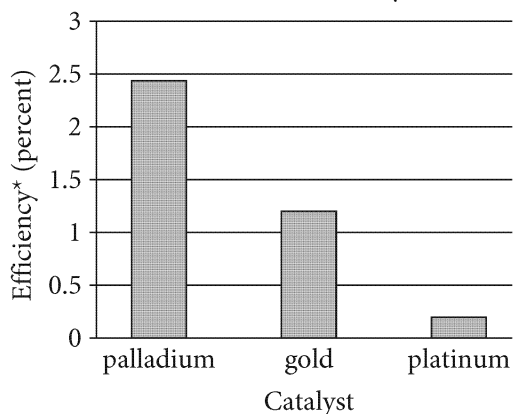
As exciting as this is, it can still be improved, and made even faster. We plan on developing more efficient catalysts that require less palladium—which is pretty expensive. Furthermore, now that we have revealed how palladium catalyzes this reaction, we hope to inspire our peers to use this principle to address other fuel synthesis reactions using electricity that can be derived from solar or wind. We believe that research efforts in this field will eventually lead to development of scalable room-temperature ammonia manufacturing.

**Figure 1**

Ammonia Yield Rate with Palladium,  
Gold, and Platinum Catalysts

**Figure 2**

Efficiency of Palladium, Gold,  
and Platinum Catalysts



\*Efficiency: electric charge used to produce ammonia as a percentage of total charge available

Figures adapted from Jun Wang et al., "Ambient Ammonia Synthesis via Palladium-Catalyzed Electrohydrogenation of Dinitrogen at Low Overpotential." ©2018 by Jun Wang et al.

The researchers also tested gold and platinum, other known catalysts of ammonia synthesis.

22

It can reasonably be inferred from the passage that the global need for ammonia will

- A) begin to decline as agriculture decreasingly relies on fertilizers.
- B) change depending on the annual climate fluctuations that farming regions experience.
- C) increase as more ammonia is required to meet the expanding need for agriculture.
- D) stabilize when production is supported by a renewable energy source such as solar power.

23

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 1-4 ("Ammonia . . . chemical")
- B) Lines 5-10 ("Manufacturing . . . production")
- C) Lines 11-16 ("With . . . electricity")
- D) Lines 20-26 ("Ammonia . . . reaction")

24

Which statement best describes the overall structure of the passage?

- A) The author summarizes the steps of a new chemical process used in the agriculture industry, provides several reasons why the process is superior to other methods, and then proposes further improvements to the process.
- B) The author explains an important chemical manufacturing process that needs improvement, presents research to identify a more effective production method, and then offers proposals for further research.
- C) The author reports a disturbing development in the agriculture industry, details research related to this development, and then offers several predictions about the application of this research to the industry.
- D) The author describes the chemical components of an essential ingredient in fertilizer, alludes to research showing that the ingredient is rapidly being depleted, and then advocates for alternative ways of producing the ingredient.

25

As used in line 1, “critical” most nearly means

- A) fundamental.
- B) particular.
- C) demanding.
- D) pressing.

26

It can most reasonably be inferred from the passage that the author’s team initially sought to answer which question concerning the production of ammonia?

- A) Does the introduction of a catalyst at lower temperatures impede the production of ammonia?
- B) Is electrical energy alone effective in the production of ammonia from nitrogen and water?
- C) What is the most valuable chemical that can be produced on an industrial scale from nitrogen and water?
- D) How does the electrochemical method of ammonia production differ from the Haber-Bosch process?

27

As used in line 41, “inspired” most nearly means

- A) influenced.
- B) uplifted.
- C) produced.
- D) animated.

28

Which choice best supports the idea that as a catalyst in the production of ammonia, palladium produced the result that the author and his team were seeking?

- A) Lines 40-44 (“After . . . dioxide”)
- B) Lines 44-47 (“As far . . . hydrogen”)
- C) Lines 48-53 (“Surprisingly . . . *Communications*”)
- D) Lines 69-70 (“As exciting . . . faster”)

29

The eighth paragraph (lines 64-68) mainly serves to

- A) note a challenge in designing an experiment.
- B) introduce a new idea for scientific consideration.
- C) summarize the findings of an experiment.
- D) illustrate how a scientific idea was validated.

30

According to the author, which characteristic of palladium is important for his team members to consider in perfecting their electrochemical method of ammonia production?

- A) Toxicity
- B) Durability
- C) Luster
- D) Cost

31

Which claim from the passage is best supported by the data in figure 1?

- A) Palladium has been a useful catalyst in a previous electrochemical conversion involving carbon dioxide.
- B) The Haber-Bosch method of ammonia production uses a great deal of energy from fossil fuel sources.
- C) Some established catalysts synthesize ammonia at a slower rate than does palladium.
- D) A palladium catalyst may produce undesirable elements, such as hydrogen.

32

Based on the passage, how would the author most likely explain the difference in the efficiency of the palladium, gold, and platinum catalysts, as shown in figure 2?

- A) A transitional stage exclusive to the reaction between water and palladium allows for more efficient production of ammonia.
- B) The reaction between palladium and the carbon atoms allows for an unknown efficient reaction as compared with reactions involving gold and platinum.
- C) The reaction between water and gold or platinum is much slower than reactions catalyzed by palladium because of the interference of excess hydrogen.
- D) The reaction of palladium and water can occur at room temperature, whereas the reactions of gold and platinum require higher temperatures.

**Questions 33-42 are based on the following passage.**

This passage is adapted from a speech delivered in 1918 by Jeannette Rankin, During the First World War, Representative Rankin spoke at a congressional debate about amending the US Constitution to grant woman suffrage.

Line It is time for our old political doctrines to give  
way to the new visions, the new aspects of national  
and international relations which have come to us  
already since the war began. For we have had new  
5 visions; we have been aroused to a new way of  
looking at things. Our President,<sup>1</sup> with his wisdom  
and astuteness, has helped us to penetrate new  
problems, to analyze situations, to make fine  
distinctions. He startled us by urging us to  
10 distinguish between the German government<sup>2</sup> and  
the German people. We who have been steeped in  
democratic ideals since the days when our forefathers  
signed the Declaration of Independence find it  
difficult to think of government as something  
15 separate from the people.

Yet as we learn to make this distinction for  
Germany, will not our minds revert to our own  
situation and be puzzled? How can people in other  
countries who are trying to grasp our plan of  
20 democracy avoid stumbling over our logic when we  
deny the first steps in democracy to our women?  
May they not see a distinction between the  
government of the United States and the women of  
the United States?

25 Deep down in the hearts of the American people  
is a living faith in democracy. Sometimes it is not  
expressed in the most effective way. Sometimes it  
seems almost forgotten. But when the test comes, we  
find it still there, groping and aspiring and helping  
30 men and women to understand each other and their  
common need. It is our national religion and it  
prompts in us the desire for that measure of justice  
which is based on equal opportunity, equal  
protection, equal freedom for all. In our hearts we  
35 know that desire can be realized only when  
“those who submit to authority have a voice in their  
own government”—whether that government be  
political, industrial or social.

Today there are men and women in every field of  
40 endeavor who are bending all their energies toward a  
realization of this dream of universal justice. They  
believe that we are waging a war for democracy. The  
farmer who knows the elements of democracy

becomes an idealist when he contemplates the  
45 possibility of feeding the world during this crisis. The  
woman who knits all day to keep from thinking of  
the sacrifice she is making wonders what this  
democracy is which she is denied and for which she  
is asked to give. The miner is dreaming his dreams of  
50 industrial democracy as he goes about 2,000 feet  
underground, bringing forth from the rock precious  
metals to help in the prosecution of this war. . . .

The boys at the front know something of the  
democracy for which they are fighting. These  
55 courageous lads who are paying with their lives  
testified to the sincerity of their fight when they sent  
home their ballots in the New York election, and  
voted two to one in favor of woman suffrage and  
democracy at home.

60 These are the people of the nation. These are the  
fiber and sinew of war—the mother, the farmer, the  
miner, the industrial worker, the soldier. These are  
the people who are giving their all for the cause of  
democracy. These are the people who are resting  
65 their faith in the Congress of the United States  
because they believe that Congress knows what  
democracy means. These people will not fight in  
vain.

Can we afford to allow these men and women to  
70 doubt for a single instant the sincerity of our  
protestations of democracy? How shall we answer  
their challenge, gentlemen? How shall we explain to  
them the meaning of democracy if the same  
Congress that voted for war to make the world safe  
75 for democracy refuses to give this small measure of  
democracy to the women of our country?

<sup>1</sup> Woodrow Wilson

<sup>2</sup> A federal monarchy

33

The main claim of the passage is that

- A) it is essential that Americans make distinctions between the German government and the German people.
- B) denying women suffrage in the United States is inconsistent with the democratic ideals that the country is fighting to uphold abroad.
- C) there are many ways that Americans can contribute to the war effort at home and abroad.
- D) the United States has a better chance of winning the war if Congress supports women suffrage.

34

It can most reasonably be inferred from the passage that Rankin believes that periods of conflict represent an opportunity to

- A) reform traditional attitudes to match changing reality.
- B) repair division between political leaders and the public.
- C) question the depth of people's commitments to cherished ideals.
- D) reinforce people's conceptions of national identity.

35

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 1-4 ("It is . . . began")
- B) Lines 9-11 ("He startled . . . people")
- C) Lines 25-26 ("Deep . . . democracy")
- D) Lines 31-34 ("It is . . . all")

36

Based on the passage, what reason would Rankin likely suggest for why it is wrong for a democratic government to deny suffrage to women?

- A) The full set of essential liberties and protections in a democracy is unavailable to those denied the right to choose elected representatives.
- B) The nation's founding documents enshrine the principle that a representative government is invalid if rights are restricted.
- C) Only if both men and women have the right to vote can people address the serious problems that arise in a democracy.
- D) People's faith in democracy is weakened when there is a continual need to remind national leaders of its tenets.

37

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 11-15 ("We who . . . people")
- B) Lines 22-24 ("May . . . States")
- C) Lines 28-31 ("But when . . . need")
- D) Lines 34-38 ("In our . . . social")

38

As used in line 19, "grasp" most nearly means

- A) hold.
- B) catch.
- C) understand.
- D) enclose.



39

In the passage, Rankin indicates that Americans' faith in democratic principles

- A) is regularly affirmed despite ongoing challenges to those values.
- B) has wavered when national policy has failed to prioritize these ideals.
- C) has weakened after attempts by other countries to undermine the United States.
- D) remains solid as a result of citizens' interventions in American politics.

40

According to Rankin, service to the United States during the war

- A) has indicated historically high levels of patriotic enthusiasm.
- B) has declined due to the soldiers' growing lack of confidence in Congress's motives.
- C) is being overlooked by both the government and the general public.
- D) is being undertaken through the performance of a variety of combat and noncombat roles.

41

In the fourth paragraph (lines 39-52), Rankin supports her claims about democracy by using which kind of evidence?

- A) Personal anecdotes about Americans who enlisted in the army to protect democracy
- B) Hypothetical examples of the variety of ways Americans are already promoting democracy
- C) Speculations about how future generations of Americans will demonstrate their commitment to democratic principles
- D) Narratives of Americans striving to establish democratic ideals throughout US history

42

Rankin's mention of the New York election mainly serves to

- A) counter international critics who claim that Americans refuse to provide equal rights to women.
- B) highlight the determination of the soldiers who insisted on voting while fighting abroad.
- C) foreshadow the likelihood of high vote counts for women suffrage in other state elections.
- D) demonstrate the soldiers' commitment to ensuring an equal application of democratic principles.

**Questions 43-52 are based on the following passages.**

Passage 1 is adapted from “‘Super-Earths’ Will Have Plate Tectonics, Scientists Predict.” ©2007 by PhysOrg.com.

Passage 2 is adapted from Shannon Hall, “Earth’s Tectonic Activity May Be Crucial for Life—and Rare in Our Galaxy.” ©2017 by Scientific American, a division of Springer Nature America, Inc. Plate tectonics is the movement of the plates of Earth’s crust and upper mantle.

**Passage 1**

Earth is the only known planet that has plate tectonics, and this activity has been proposed as one necessary condition for the evolution of life.

Line However, planetary scientist Diana Valencia and  
5 her colleagues predict that super-Earths—exoplanets that are between one and ten times as massive as Earth—will fulfill one of the requirements for sustaining life by having plate tectonics.

“Some of these super-Earths may be in the  
10 ‘habitable zone’ of their solar systems, meaning they are at the right distance from their mother star to have liquid water, and thus life,” Valencia, the paper’s corresponding author, said. “Ultimately, though, only these planets’ thermal and chemical  
15 evolution will determine whether they are habitable. But these thermal and chemical properties are closely tied to plate tectonics.”

Using detailed models they developed of the interior of massive terrestrial planets, Valencia and  
20 her group determined how the mass of a super-Earth is related to the thickness of its plates and the magnitude of the stresses the plates experience. These stresses, part of the slow, slow convection of Earth’s mantle, are the driving force behind the  
25 deformation and subduction (when one plate sinks below another) of the plates. For planets more massive than Earth, this driving force is larger than Earth’s.

The group found that as planetary mass increases,  
30 there is an increase in the shear stress [stress parallel to a plate’s surface] and a decrease in the plate thickness. Both of these factors weaken the plates and contribute to plate subduction, which is a key component of plate tectonics. Therefore, the  
35 scientists say, the conditions required for plate deformation and subduction are easily met by super-Earths. Their results show that this is particularly true for the larger super-Earths.

“Our work strongly suggests that super-Earths,  
40 even if they have no water, will exhibit plate tectonic behavior,” Valencia said.

**Passage 2**

In 2007 planetary scientist Diana Valencia concluded that super-Earths (rocky planets larger than ours) are so likely to host plate tectonics, it is  
45 practically inevitable. Because planets more massive than Earth would retain significantly more internal heat from their initial formation, and because heat drives plate tectonics (via the conveyor belt of sinking and rising rock within the mantle), plate  
50 activity should be prolonged on such planets. The trouble is that Valencia’s study (and many studies that came later) analyzed only one parameter: a planet’s size. A 2017 study by astronomer Cayman Unterborn is among the first to address plate  
55 tectonics based on a planet’s composition.

To carry out this analysis, Unterborn and his colleagues needed to determine what an exoplanet’s chemical composition might look like. Although astronomers can currently decipher the elements  
60 within an exoplanet’s atmosphere, there is no way to peer deep into an exoplanet’s rocky interior—yet. So Unterborn and his team turned toward the planets’ host stars. Because the stars and their planets are built from the same swirling disk of dust and gas,  
65 they tend to be made of the same stuff. The researchers looked at nearly 1,500 stars (including 123 stars observed with the Kepler space telescope that astronomers know have orbiting exoplanets) and then used computer models to discover how  
70 rocks of these varying compositions would react to the high interior temperatures and pressures formed in a planet.

Once they had an idea of what an exoplanet’s mantle and crust might look like, geochemically  
75 speaking, the scientists were able to determine whether that exoplanet’s crust would be dense enough to sink into the mantle, just as Earth’s oceanic plates do at places like the Cascadia subduction zone—North America’s 1,000-kilometer-  
80 long chain of volcanoes built as one plate takes a deep dive beneath another. Making the calculation involved rigorous modeling: As pressures and temperatures mount during a plate’s descent, atoms in the plate undergo a reorganization that makes the  
85 plate denser. Should the plate remain denser than the

surrounding mantle then the plate would continue to sink. If that is the case, plate tectonics might thrive for billions of years. But if it does not and the plate stalls, then plate tectonics would shut down,

90 crippling life's chances.

The results paint a rather depressing result as far as habitability is concerned: At least two thirds of the simulated planets build a crust that is too buoyant to sink.

43

As used in line 40, "exhibit" most nearly means

- A) unveil.
- B) express.
- C) display.
- D) model.

44

As used in line 18, "detailed" most nearly means

- A) organized.
- B) precise.
- C) decorated.
- D) abundant.

45

Based on Passage 1, Valencia's findings suggest that a planet that is substantially less massive than another planet is

- A) more likely than is the more massive planet to have plates that are strong enough to resist tectonic movements.
- B) less likely than is the more massive planet to have plates that are strong enough to withstand deformation.
- C) more likely than is the more massive planet to have smaller plates whose tectonic movement quickly accelerates.
- D) less likely than is the more massive planet to have plates large enough to maintain tectonic movement.

46

According to Passage 2, Unterborn and his team predicted exoplanets' chemical composition by

- A) inferring the composition of such planets based on the stars they orbit.
- B) assuming the proportion of elements in such planets' atmospheres is representative of the composition of their mantles.
- C) modeling exoplanets' interiors based on nearby planets with established chemical compositions.
- D) establishing the likely geochemical composition of such planets based on their suspected thermal conditions.

47

It can most reasonably be inferred from Passage 2 that Unterborn and his team took which factor into consideration when designing their study?

- A) The crusts of super-Earths likely contain the same chemical elements as their atmospheres.
- B) The density of a planet's plates will likely change as subduction occurs.
- C) Most planets have mantles that are denser than the materials that make up their crusts.
- D) Most stars have chemical compositions that are identical to the star that Earth orbits.

48

Which choice provides the best evidence for the answer to the previous question?

- A) Lines 58-61 ("Although . . . yet")
- B) Lines 65-72 ("The researchers . . . planet")
- C) Lines 73-81 ("Once . . . another")
- D) Lines 81-85 ("Making . . . denser")

49

Which choice best states the relationship between the passages?

- A) Passage 1 reaches a conclusion, and Passage 2 affirms the conclusion.
- B) Passage 1 reports a finding, and Passage 2 elaborates on the finding.
- C) Passage 2 discredits the research methods explained in Passage 1.
- D) Passage 2 casts doubt on a key finding described in Passage 1.

50

The authors of both passages agree on which point?

- A) The presence of liquid water on a planet is closely related to whether that planet will have plate tectonics.
- B) The habitability of a planet is related to the existence of plate tectonics on that planet.
- C) The density of a planet's crust will determine whether subduction of that planet's plates is possible.
- D) The distance of a planet from its host star is directly correlated to the likelihood that that planet has tectonic activity.

51

In response to the findings stated in lines 34-37, Passage 1 ("Therefore . . . Earths"), the author of Passage 2 would most likely point out that

- A) the crusts of the super-Earths lack the thermal energy needed to cause deformation and subduction.
- B) conditions required for plate tectonics to occur vary according to the mass of the planet.
- C) the buoyancy of most super-Earths' plates overcomes other forces that sustain ongoing plate deformation and subduction.
- D) there is no direct method for analyzing the geochemical composition of super-Earths.

52

Which choice from Passage 2 provides the best evidence for the answer to the previous question?

- A) Lines 45-50 ("Because . . . planets")
- B) Lines 63-65 ("Because . . . stuff")
- C) Lines 85-88 ("Should . . . years")
- D) Lines 91-94 ("The results . . . sink")

## STOP

**If you finish before time is called, you may check your work on this section only.  
Do not turn to any other section.**

**No Test Material On This Page**

# Writing and Language Test

35 MINUTES, 44 QUESTIONS

Turn to Section 2 of your answer sheet to answer the questions in this section.

## DIRECTIONS

Each passage below is accompanied by a number of questions. For some questions, you will consider how the passage might be revised to improve the expression of ideas. For other questions, you will consider how the passage might be edited to correct errors in sentence structure, usage, or punctuation. A passage or a question may be accompanied by one or more graphics (such as a table or graph) that you will consider as you make revising and editing decisions.

Some questions will direct you to an underlined portion of a passage. Other questions will direct you to a location in a passage or ask you to think about the passage as a whole.

After reading each passage, choose the answer to each question that most effectively improves the quality of writing in the passage or that makes the passage conform to the conventions of standard written English. Many questions include a “NO CHANGE” option. Choose that option if you think the best choice is to leave the relevant portion of the passage as it is.

Questions 1-11 are based on the following passage and supplementary material.

### A Dog Knows What It Noses

Dogs have long been famous for their powerful noses. For millennia, humans across many hunting cultures have employed dogs as trackers, marveling at their keen sense of smell. Today, scientific research has only confirmed the common knowledge that the domestic dog (*Canis familiaris*) is endowed with olfactory capabilities more acute than **1** that of the average human—up to 100,000 times more, in fact. In a 2005 study led by behavioral psychologists in Northern Ireland, dogs proved they just needed five footsteps to

1

- A) NO CHANGE
- B) the average human’s—
- C) those of the average humans—
- D) the average human—

determine by smell which direction a person had walked on a given trail. While there may be little dispute regarding dogs' impressive abilities to track scents, **2** how dogs themselves perceive odors remains a tantalizing topic of inquiry.

Among those investigating dogs' cognitive relationship to olfaction are German researchers Juliane Bräuer and Julia Belger. **3** In 2018 Bräuer and Belger published a study in the *Journal of Comparative Psychology*. In the study, they sought to learn if dogs mentally represent what they smell. **4** In other words, the scientists wondered whether dogs have expectations of what they search for or whether they simply **5** have followed a trail of positive stimuli.

2

Which choice best sets up the information in the next paragraph?

- A) NO CHANGE
- B) why dogs eat what they eat may be explained by the fact that dogs have considerably fewer taste buds than humans do.
- C) dogs are among a small group of animals that exhibit voluntary unselfish kindness toward others.
- D) studies show dogs may even track scents in their dreams.

3

Which choice most effectively combines the sentences at the underlined portion?

- A) In the *Journal of Comparative Psychology*, Bräuer and Belger published their study in 2018, in which they
- B) By publishing a study in 2018 in the *Journal of Comparative Psychology*, Bräuer and Belger had
- C) Bräuer and Belger published their study in 2018 in the *Journal of Comparative Psychology*, thus they
- D) In a study published in the *Journal of Comparative Psychology* in 2018, Bräuer and Belger

4

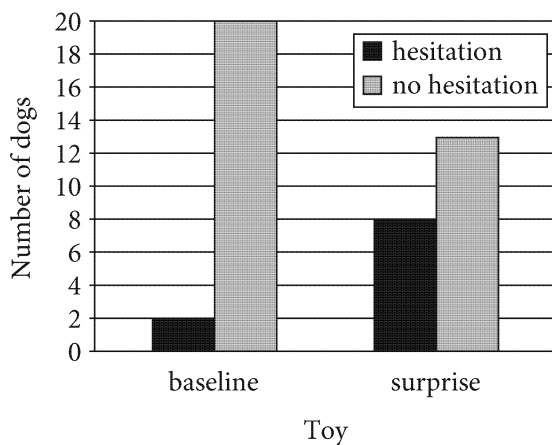
- A) NO CHANGE
- B) Nevertheless,
- C) However,
- D) As a result,

5

- A) NO CHANGE
- B) follow
- C) will have followed
- D) followed

Bräuer and Belger's study presented dogs of **6** various breeds ages, and levels of training with a violation-of-expectation test, in which dogs were tasked with tracking and fetching a familiar toy hidden in a room. Each dog, following an odor trail left by the researchers, found either the expected (baseline) toy or an unfamiliar (surprise) one. **7** Therefore, the researchers recorded the dogs' reactions. In the first trial, they observed that when the dogs found the baseline toy at the end of the search, only 2 dogs hesitated and 20 did not in fetching the toy. In contrast, significantly more dogs **8** (2) hesitated to fetch the surprise toy. Curiously, in subsequent trials fewer dogs showed hesitation in fetching both the baseline and surprise toys.

Hesitation in Dogs Fetching Expected (Baseline) and Unfamiliar (Surprise) Toy in First Trial



Adapted from Juliane Bräuer and Julia Belger, "A Ball is Not a Kong: Odor Representation and Search Behavior in Domestic Dogs (*Canis familiaris*) of Different Education." ©2018 by American Psychological Association.

6

- A) NO CHANGE
- B) various, breeds, ages, and
- C) various breeds, ages, and
- D) various breeds, ages, and,

7

- A) NO CHANGE
- B) In contrast,
- C) For example,
- D) Meanwhile,

8

Which choice most accurately represents the information in the graph?

- A) NO CHANGE
- B) (8)
- C) (11)
- D) (20)



Bräuer and Belger **9** concluded, that, based on the hesitancy exhibited in the first trial, the dogs did indeed know what they were sniffing for. Furthermore, the findings suggest that dogs can individuate objects by **10** type; a capability once thought unique to humans and apes. The **11** dissidences in the later trials, the researchers explained, only underscore the flexibility of dogs' searching behaviors: the dogs learned that they would get a treat regardless of whether they retrieved the correct toy. No further proof may be necessary to convince dog lovers of the complexity of their canine companions' inner lives, but studies such as Bräuer and Belger's help expand the scientific understanding of how dogs experience the world.

9

- A) NO CHANGE
- B) concluded, that
- C) concluded that—
- D) concluded that,

10

- A) NO CHANGE
- B) type. A
- C) type, a
- D) type a

11

- A) NO CHANGE
- B) divergences
- C) diversities
- D) disagreements

Questions 12-22 are based on the following passage and supplementary material.

**Before We Buy, They Buy**

**12** Shira Suveyke took a big risk in her career, and it ultimately paid off. As a retail merchandise buyer for online fashion retailer the Outnet, Suveyke can only do her best to predict which pieces of clothing will appeal to customers in order to decide which products will be sold on the company's website. Suveyke must make key purchasing decisions that balance both market and aesthetic **13** considerations. To ensure that the right items are in stock when customers want them.

**12**

Which choice provides the most effective introduction to the paragraph?

- A) NO CHANGE
- B) In order to manage her international team of buyers, Shira Suveyke often works nights.
- C) Shira Suveyke joined the fashion industry in 2011 and works with over 350 designer brands.
- D) It would be helpful for Shira Suveyke to be able to foresee the future.

**13**

- A) NO CHANGE
- B) considerations, to
- C) considerations to
- D) considerations; to

[1] In a global online marketplace, a merchandise buyer like Suveyke must carefully consider the varied preferences of a diverse customer base. [2] Consumer trends can vary not only from country to country but also from region to region within the same country.

[3] Suveyke analyzes years of customer data to target purchasing decisions for each market. [4] Suveyke, who began her career in finance before moving into the fashion industry, contends that a successful buyer needs to be **14** savvy in both a fashion and a business sense.

[5] Good buyers, she says, need analytical skills, **15** an eyeing for quality, and the confidence to act on instinct when products appeal to them. [6] These proficiencies are typically gained through a combination of formal education—many retail buyers major in retail merchandising, business, or **16** fashion, and practical experience such as internships or jobs in retail establishments. **17**

14

- A) NO CHANGE
- B) slick
- C) on the ball
- D) with it

15

- A) NO CHANGE
- B) the eye of
- C) an eye for
- D) the eyeing of

16

- A) NO CHANGE
- B) fashion—
- C) fashion;
- D) fashion

17

The writer wants to add the following sentence to this paragraph.

The Outnet, for example, services more than 170 countries.

To make this paragraph most logical, the sentence should be placed

- A) before sentence 1.
- B) after sentence 1.
- C) after sentence 4.
- D) after sentence 5.

With much at stake for **18** companies, if their products don't sell, merchandise buyers make purchasing decisions based on careful deliberation. A study published in 2014 in the *Journal of Retailing and Consumer Services* asked apparel merchandise buyers to rate (from 1 to 4) the factors they take into account when making purchases. Perhaps unsurprisingly, a product's **19** brand image received the lowest average rating, at 3.39. Other factors that buyers gave the highest ratings illustrate the wide range of expertise that Suveyke and others in the field must bring to their work. For instance, understanding the target customer and **20** current fashion trends each received an average rating of 3.20. Buyers also rated sales history (3.28) and budget (3.19) very highly, illustrating that they must pay attention to market research and accounting concerns.

Importance of Buying Decision Factors

| Merchandise buying decision factor | Average rating<br>(scale of 1 to 4) |
|------------------------------------|-------------------------------------|
| Seasonal appropriateness           | 3.39                                |
| Available inventory of product     | 3.33                                |
| Product sales history              | 3.28                                |
| Target customer                    | 3.20                                |
| Current fashion trends             | 3.20                                |
| Budget                             | 3.19                                |
| Product costs                      | 3.18                                |
| Product brand image                | 3.16                                |
| Previous sales of similar styles   | 3.04                                |
| Brand position in market           | 2.96                                |
| Competitor's products              | 2.81                                |

Adapted from Youngjin Bahng and Doris H. Kincade, "Retail Buyer Segmentation Based on the Use of Assortment Decision Factors."  
©2014 by Elsevier Ltd.

18

- A) NO CHANGE
- B) companies;
- C) companies:
- D) companies

19

Which choice most accurately represents the data in the table?

- A) NO CHANGE
- B) seasonal appropriateness received the highest
- C) seasonal appropriateness received the lowest
- D) brand image received the highest

20

Which choice most accurately and effectively uses the information from the table to support the idea in the previous sentence?

- A) NO CHANGE
- B) the product brand image showed a wide split in priorities among buyers.
- C) recognizing a brand's position in the market received essentially the same ratings.
- D) scouting competitors' products were given ratings below 3.21.

The results of the study certainly support Suveyke's **21** assertions. Suveyke has asserted that the career of a merchandise buyer is one that **22** mixed creativity with business acumen all in a day's work. Since fashion trends are always changing, merchandise buyers are guaranteed a dynamic and ever-evolving career—even if they can't predict the future.

21

Which choice most effectively combines the sentences at the underlined portion?

- A) assertions, though she has asserted
- B) assertions, and they are
- C) assertions; those assertions are
- D) assertions

22

- A) NO CHANGE
- B) was mixing
- C) mixes
- D) had mixed

Questions 23-33 are based on the following passage.

### In Search of Speedy Stars

It is widely believed that a Type Ia supernova occurs when a white dwarf star siphons mass from a companion star until the white dwarf becomes unstable and explodes. However, **23** the brightness of this type of supernova, at its peak, may be equivalent to up to 10 billion times that of our Sun. One model posits that an ordinary star is the culprit, while a different proposed scenario suggests another white dwarf is the companion. **24** The two models are not mutually exclusive. Of the two models, recent research provides strong empirical support for the latter—the double-degenerate model involving a pair of white dwarf stars.

23

Which choice best sets up the information that follows in the paragraph?

- A) NO CHANGE
- B) there is no consensus on the identity of the companion star within this binary system.
- C) this type of supernova is also often used as a point of comparison for measuring cosmological distance.
- D) a Type Ia supernova is distinguished from a Type Ib or a Type Ic supernova by the presence of strong silicon lines in its stellar spectrum.

24

Which choice most effectively combines the sentences at the underlined portion?

- A) Not only are the two models not mutually exclusive, but recent research in fact provides
- B) While the two models are not mutually exclusive, recent research provides
- C) Given the fact that the two models are not mutually exclusive, it is recent research that provides
- D) The two models are not mutually exclusive; additionally, what recent research has done is to provide

[1] Proponents of the double-degenerate model

**25** hypothesizes that in some cases the companion white dwarf **26** survives and is propelled away with a velocity equal to its orbital velocity prior to the explosion, but several surveys failed to identify any such so-called hypervelocity runaways. [2] In 2018, though, astronomer Ken Shen led an international team of researchers in a renewed search. [3] Shen argued that prior studies either lacked a wide enough search radius or failed to consider that the once hotter hypervelocity companion stars might have cooled since the **27** explosion, to make them harder to distinguish from other white dwarfs. **28**

25

- A) NO CHANGE
- B) has hypothesized
- C) hypothesize
- D) is hypothesizing

26

- A) NO CHANGE
- B) survives,
- C) survives, it
- D) survives: and

27

- A) NO CHANGE
- B) explosion, making
- C) explosion, and making
- D) explosion can make

28

The writer wants to add the following sentence to this paragraph.

As it turned out, Shen was right to believe that a more comprehensive survey might finally locate these runaways.

The best placement for the sentence is

- A) before sentence 1.
- B) after sentence 1.
- C) after sentence 2.
- D) after sentence 3.

Shen's team used the European Space Agency's *Gaia* spacecraft and **29** ground-based telescopes at sites across the globe to conduct an all-sky search for **30** stars that matched his description of hypervelocity runaways. Three white dwarf stars appeared as likely candidates, one of which was traveling at 8.64 million kilometers per hour, making it among the fastest known objects in the galaxy. The researchers calculated the trajectories of these stars to determine their past locations and made a key **31** discovery 90,000 years ago; one of the stars was positioned in what are now the faint remains of a supernova, suggesting its history as a companion star in a Type Ia supernova event.

29

- A) NO CHANGE
- B) also utilized ground-based telescopes at sites and places
- C) ground-based telescopes that they used at sites
- D) terrestrial, ground-based telescopes

30

- A) NO CHANGE
- B) ones that
- C) those who
- D) researchers who

31

- A) NO CHANGE
- B) discovery, 90,000 years ago:
- C) discovery: 90,000 years ago
- D) discovery, 90,000 years ago,



While these results provide support for the double-degenerate model, **32** emerging technologies have the potential to provide a greater understanding of the Milky Way galaxy. When considering high-velocity outliers such as these, warns University of Texas at Austin astronomer Keith Hawkins, “you have to be very careful about whether or not there’s something wrong with the data.” Indeed, confirmation requires additional findings, but Shen believes evidence of many other hypervelocity runaway white dwarfs may be hidden in current astronomical data. **33** Shen had not been guaranteed to find any useful data at all and was encouraged by his team’s findings.

32

Which choice best sets up the information that follows in the paragraph?

- A) NO CHANGE
- B) other researchers are curious as to how much black holes can affect star systems.
- C) some scientists are cautious not to leap to conclusions.
- D) data obtained by *Gaia* have proved useful in the explanation of several other celestial events.

33

Which choice provides the most effective conclusion to the passage?

- A) NO CHANGE
- B) If so, their discovery will bring us closer to understanding the exact process by which Type Ia supernovae occur.
- C) The challenge of finding that evidence, if it exists, may require great effort.
- D) Until that evidence appears, he hopes that other researchers will reexamine his team’s data to verify the discovery.

Questions 34-44 are based on the following passage.

### Future Library

Scottish artist Katie Paterson creates conceptual art projects that invite viewers to consider their relationship to nature, **34** with a focus on the huge immensity of space and time. For her piece *Inside this desert lies the tiniest grain of sand*, she asked nanotechnology experts to fashion the world's tiniest fragment of sand, which she then buried in the vast wastelands of the Sahara. Her *Fossil Necklace* is a necklace of 170 fossils, each symbolizing a different milestone in the development of life on Earth over billions of years. Paterson's new work, *Future Library*, explores the links between the natural world, time, and human activity in an exciting new **35** way: the project involves planting a small forest and, one hundred years later, turning **36** them into a book.

34

- A) NO CHANGE
- B) focusing on the huge
- C) with a central, main focus on the
- D) focusing on the

35

- A) NO CHANGE
- B) way and
- C) way,
- D) way; as

36

- A) NO CHANGE
- B) those
- C) it
- D) DELETE the underlined portion.

For Paterson, *Future Library* began with her interest in the relationship between books and trees. As she explained in an interview, “The idea to grow trees to print books arose through making a connection between tree rings and chapters—almost as if the trees absorb the writer’s words like air or water, and the rings become chapters, spaced out over the years to come.” Paterson had long wanted to develop a **37** project exploring the connection between writing and the natural world, and when she was hired by a group from Oslo, Norway, to create public art for the area around the city’s harbor, she saw an opportunity to **38** travel abroad.

37

- A) NO CHANGE
- B) project exploring the connection,
- C) project, exploring the connection
- D) project: exploring the connection

38

Which choice provides the most effective conclusion to the paragraph?

- A) NO CHANGE
- B) spread her love of nature.
- C) realize her vision.
- D) create art for the public to enjoy.

The project officially got underway in 2014 when Paterson and others planted 1,000 spruce trees in a forest north of Oslo. According to her plan, the trees are to be **39** handled for one hundred years. For each of those years, from 2014 to 2114, a noted author **40** is to be asked to contribute an original piece of writing; each work is to be held securely, unread, in storage in the new Oslo Public Library in the city's harbor district. Thus, as the trees grow, so too does a collection of stories, poems, and essays. At the end of the hundred-year period, the trees are to be cut down and made into paper.

**41** Because the anthology will be presented in the public library in Oslo, Paterson estimates that the trees should yield enough paper to print 3,000 copies of the full collection. Readers of the anthology will be able to **42** analyze the defining characteristics of good literature, one written work at a time.

39

- A) NO CHANGE
- B) shepherded
- C) tended
- D) regarded

40

- A) NO CHANGE
- B) are being
- C) were
- D) have been

41

Which choice provides a transition that emphasizes the length of the project?

- A) NO CHANGE
- B) While she wasn't one of the authors,
- C) Although she won't be around to see it,
- D) Despite the changes that the trees will undergo over time,

42

Which choice best reflects Paterson's goals for the project?

- A) NO CHANGE
- B) Select their favorite writings from the past,
- C) chart the history of the previous one hundred years,
- D) examine the writing development of one hundred great authors,

The first writer to be asked to contribute to the anthology, Canadian author Margaret Atwood, submitted a piece titled “Scribbler Moon” in 2015. **43** Reflecting on the **44** experience, so Atwood captured the beauty and mystery of Paterson’s project: “Will there be a ‘forest’? Will there be a ‘library’? How strange it is to think of my own voice—silent by then for a long time—suddenly being awakened, after 100 years.”

43

At this point, the writer is considering adding the following sentence.

Although no one has yet read Atwood’s contribution, it is likely to be a favorite of Canadian readers one hundred years from now.

Should the writer make this addition here?

- A) Yes, because it reiterates Paterson’s plan for the project not to be completed until one hundred years have passed.
- B) Yes, because it establishes a hypothesis about the popularity of the project that is discussed in the paragraph.
- C) No, because it repeats information about Paterson’s project that is provided elsewhere in the passage.
- D) No, because it blurs the paragraph’s focus by introducing an unsupported claim that is irrelevant to Atwood’s reflection on this experience.

44

- A) NO CHANGE
- B) experience,
- C) experience and
- D) experience;

# STOP

**If you finish before time is called, you may check your work on this section only.  
Do not turn to any other section.**



# Math Test – No Calculator

25 MINUTES, 20 QUESTIONS

Turn to Section 3 of your answer sheet to answer the questions in this section.

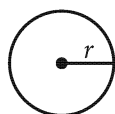
## DIRECTIONS

For questions 1-15, solve each problem, choose the best answer from the choices provided, and fill in the corresponding bubble on your answer sheet. For questions 16-20, solve the problem and enter your answer in the grid on the answer sheet. Please refer to the directions before question 16 on how to enter your answers in the grid. You may use any available space in your test booklet for scratch work.

## NOTES

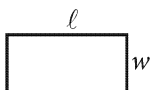
1. The use of a calculator **is not permitted**.
2. All variables and expressions used represent real numbers unless otherwise indicated.
3. Figures provided in this test are drawn to scale unless otherwise indicated.
4. All figures lie in a plane unless otherwise indicated.
5. Unless otherwise indicated, the domain of a given function  $f$  is the set of all real numbers  $x$  for which  $f(x)$  is a real number.

## REFERENCE

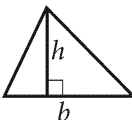


$$A = \pi r^2$$

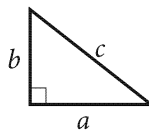
$$C = 2\pi r$$



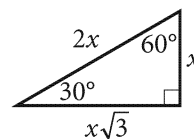
$$A = \ell w$$



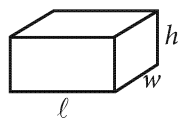
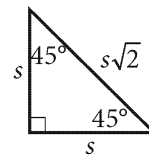
$$A = \frac{1}{2}bh$$



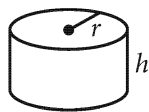
$$c^2 = a^2 + b^2$$



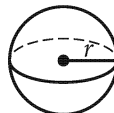
Special Right Triangles



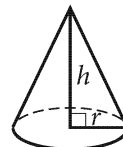
$$V = \ell wh$$



$$V = \pi r^2 h$$



$$V = \frac{4}{3}\pi r^3$$



$$V = \frac{1}{3}\pi r^2 h$$



$$V = \frac{1}{3}\ell wh$$

The number of degrees of arc in a circle is 360.

The number of radians of arc in a circle is  $2\pi$ .

The sum of the measures in degrees of the angles of a triangle is 180.



1

A meteorite with a mass of 16.0 grams (g) is composed of iron and nickel and has a volume of 2.0 cubic centimeters ( $\text{cm}^3$ ). Iron has a density of 7.9 grams per cubic centimeter ( $\text{g}/\text{cm}^3$ ), and nickel has a density of 8.9  $\text{g}/\text{cm}^3$ . Which system of equations represents this situation, where  $r$  is the volume of iron and  $n$  is the volume of nickel in the meteorite?

A)  $7.9r + 8.9n = 16.0$   
 $r + n = 2.0$

B)  $7.9r + 8.9n = 16.0$   
 $r + n = 16.0$

C)  $7.9r + 8.9n = 2.0$   
 $r + n = 2.0$

D)  $7.9r + 8.9n = 2.0$   
 $r + n = 16.0$

2

Which expression is equivalent to  $\frac{8x}{4}$ ?

A)  $2x$

B)  $4x$

C)  $\frac{1}{2x}$

D)  $\frac{x}{2}$

3

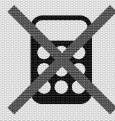
The function  $f$  is defined as  $f(x) = x^3 + 5$ . What is the value of  $f(3)$ ?

A) 14

B) 27

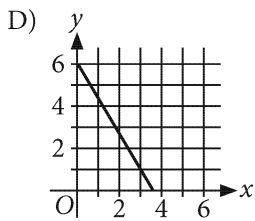
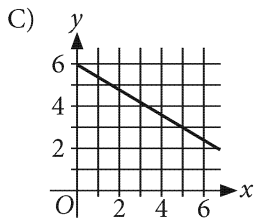
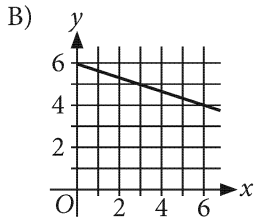
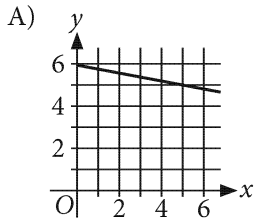
C) 32

D) 38



4

The function  $g$  is defined by  $g(x) = -\frac{3}{5}x + 6$ . What is the graph of  $y = g(x)$ ?

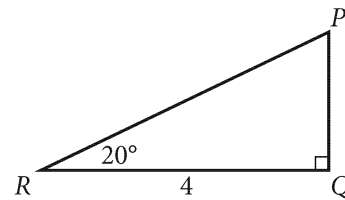


5

The equation  $2x + 30y = 4,700$  models the total number of trees in a neighborhood consisting of a 2-hectare park and a 30-hectare residential area. The total number of trees in the neighborhood is 4,700. Which is the best interpretation of  $x$  in this context?

- A) The total number of trees in the park
- B) The number of trees per hectare in the park
- C) The total number of trees in the residential area
- D) The number of trees per hectare in the residential area

6



In triangle  $PQR$  shown, what is the length of  $\overline{PQ}$ ?

- A)  $4 \cos 20^\circ$
- B)  $\frac{\cos 20^\circ}{4}$
- C)  $4 \tan 20^\circ$
- D)  $\frac{4}{\tan 20^\circ}$





7

$$g(x) = 2\left(\frac{1}{2}\right)^x$$

If the given function  $g$  is graphed in the  $xy$ -plane, where  $y = g(x)$ , what is the  $y$ -intercept of the graph?

- A) (0, 0)
- B) (0, 1)
- C) (0, 2)
- D) (0, 4)

8

Line  $\ell$  in the  $xy$ -plane contains the points (0, -2) and (10, 4). An equation of line  $\ell$  is  $y = mx + b$ , where  $m$  and  $b$  are constants. What is the value of  $m$ ?

- A)  $\frac{5}{3}$
- B)  $\frac{3}{5}$
- C)  $-\frac{3}{5}$
- D)  $-\frac{5}{3}$

9

$$|x - 4| = 19$$

What are all the solutions to the given equation?

- A) 23 only
- B) 15 only
- C) 15 and -23
- D) -15 and 23

10

$$(y + g)(kx + g) = 1$$

The given equation relates the positive numbers  $g$ ,  $k$ ,  $x$ , and  $y$ . Which equation correctly express  $y$  in terms of  $g$ ,  $k$ , and  $x$ ?

- A)  $y = \frac{1}{kx + g} - g$
- B)  $y = \frac{1 - g}{kx + g}$
- C)  $y = 1 - kx - 2g$
- D)  $y = kx - g$



11

$$(8,466 + 100y^2) - 10(11y^2 + 120)$$

The given expression can be written in the form  $ay^2 + b$ , where  $a$  and  $b$  are constants. What is the value of  $a + b$ ?

- A) 9,656
- B) 8,576
- C) 7,266
- D) 7,256

12

A construction company purchased an excavator for \$180,000. The value of the excavator is expected to decrease by 12% each year. Which equation models the value of the excavator  $V(t)$ , in dollars, where  $t$  represents the number of years since purchase?

- A)  $V(t) = 180,000(0.12)^t$
- B)  $V(t) = 180,000(0.88)^t$
- C)  $V(t) = 180,000(1.12)^t$
- D)  $V(t) = 180,000(1.2)^t$

13

Which equation has no solutions?

- A)  $3(x + 5) = 3x$
- B)  $3(x + 5) = 6x$
- C)  $3x + 5 = 3x + 5$
- D)  $3x + 5 = 6x + 5$



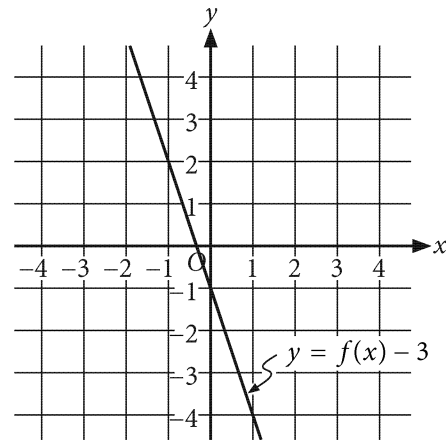
14

Triangle  $PQR$  is an isosceles triangle with base angles measuring  $45^\circ$ . Triangle  $P'Q'R'$  is similar to triangle  $PQR$ . The length of each side of triangle  $P'Q'R'$  is 1.5 times as large as the corresponding side of triangle  $PQR$ . What is the measure of each of the base angles of triangle  $P'Q'R'$  ?

- A)  $22.5^\circ$
- B)  $45^\circ$
- C)  $67.5^\circ$
- D)  $90^\circ$

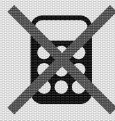
15

The graph of  $y = f(x) - 3$  is shown.




Which equation defines the linear function  $f$  ?

- A)  $f(x) = -3x - 4$
- B)  $f(x) = -3x - 3$
- C)  $f(x) = -3x + 2$
- D)  $f(x) = -3x + 8$

**DIRECTIONS**

For questions 16-20, solve the problem and enter your answer in the grid, as described below, on the answer sheet.

- Although not required, it is suggested that you write your answer in the boxes at the top of the columns to help you fill in the bubbles accurately. You will receive credit only if the bubbles are filled in correctly.
- Mark no more than one bubble in any column.
- No question has a negative answer.
- Some problems may have more than one correct answer. In such cases, grid only one answer.
- Mixed numbers** such as  $3\frac{1}{2}$  must be gridded as 3.5 or  $7/2$ . (If  is entered into the grid, it will be interpreted as  $\frac{31}{2}$ , not  $3\frac{1}{2}$ .)
- Decimal answers:** If you obtain a decimal answer with more digits than the grid can accommodate, it may be either rounded or truncated, but it must fill the entire grid.

**Answer:  $\frac{7}{12}$**

Write answer in boxes. →

|                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
| 7                     | /                     | 1                     | 2                     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1                     | 1                     | 1                     | 1                     |
| 2                     | 2                     | 2                     | 2                     |
| 3                     | 3                     | 3                     | 3                     |
| 4                     | 4                     | 4                     | 4                     |
| 5                     | 5                     | 5                     | 5                     |
| 6                     | 6                     | 6                     | 6                     |
| 7                     | 7                     | 7                     | 7                     |
| 8                     | 8                     | 8                     | 8                     |
| 9                     | 9                     | 9                     | 9                     |

Grid in result. →

← Fraction line

**Answer: 2.5**

|                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
|                       | 2                     | .                     | 5                     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1                     | 1                     | 1                     | 1                     |
| 2                     | 2                     | 2                     | 2                     |
| 3                     | 3                     | 3                     | 3                     |
| 4                     | 4                     | 4                     | 4                     |
| 5                     | 5                     | 5                     | 5                     |
| 6                     | 6                     | 6                     | 6                     |
| 7                     | 7                     | 7                     | 7                     |
| 8                     | 8                     | 8                     | 8                     |
| 9                     | 9                     | 9                     | 9                     |

← Decimal point

Acceptable ways to grid  $\frac{2}{3}$  are:

|                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
|                       | 2                     | /                     | 3                     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1                     | 1                     | 1                     | 1                     |
| 2                     | 2                     | 2                     | 2                     |
| 3                     | 3                     | 3                     | 3                     |
| 4                     | 4                     | 4                     | 4                     |
| 5                     | 5                     | 5                     | 5                     |
| 6                     | 6                     | 6                     | 6                     |
| 7                     | 7                     | 7                     | 7                     |
| 8                     | 8                     | 8                     | 8                     |
| 9                     | 9                     | 9                     | 9                     |

|                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
| .                     | 6                     | 6                     | 6                     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1                     | 1                     | 1                     | 1                     |
| 2                     | 2                     | 2                     | 2                     |
| 3                     | 3                     | 3                     | 3                     |
| 4                     | 4                     | 4                     | 4                     |
| 5                     | 5                     | 5                     | 5                     |
| 6                     | 6                     | 6                     | 6                     |
| 7                     | 7                     | 7                     | 7                     |
| 8                     | 8                     | 8                     | 8                     |
| 9                     | 9                     | 9                     | 9                     |

|                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
| .                     | 6                     | 6                     | 7                     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1                     | 1                     | 1                     | 1                     |
| 2                     | 2                     | 2                     | 2                     |
| 3                     | 3                     | 3                     | 3                     |
| 4                     | 4                     | 4                     | 4                     |
| 5                     | 5                     | 5                     | 5                     |
| 6                     | 6                     | 6                     | 6                     |
| 7                     | 7                     | 7                     | 7                     |
| 8                     | 8                     | 8                     | 8                     |
| 9                     | 9                     | 9                     | 9                     |

**Answer: 201 – either position is correct**

|                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
|                       | 2                     | 0                     | 1                     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1                     | 1                     | 1                     | 1                     |
| 2                     | 2                     | 2                     | 2                     |
| 3                     | 3                     | 3                     | 3                     |

|                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
| 2                     | 0                     | 1                     |                       |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 1                     | 1                     | 1                     | 1                     |
| 2                     | 2                     | 2                     | 2                     |
| 3                     | 3                     | 3                     | 3                     |

**NOTE:**

You may start your answers in any column, space permitting. Columns you don't need to use should be left blank.



16

$$\begin{aligned}6x - 2y &= 10 \\ -4x + 2y &= 4\end{aligned}$$

The solution to the given system of equations is  $(x, y)$ . What is the value of  $y$ ?

17

$$x(x - 2)(3x - 1) = 0$$

What is the sum of the three values of  $x$  that satisfy the equation above?

18

If  $3x + 5 + x + 7 = 36$ , what is the value of  $5x$ ?

19

$$f(x) = (x - a)(x - b)$$

The function  $f$  is defined above, where  $a$  and  $b$  are integer constants. If  $f(1) > 0$ ,  $f(4) < 0$ , and  $f(7) > 0$ , what is one possible value of  $a + b$ ?

20

$$x^2 + y^2 + 2x - 8y = 8$$

The equation of a circle in the  $xy$ -plane is shown above. What is the radius of the circle?

**STOP**

**If you finish before time is called, you may check your work on this section only.  
Do not turn to any other section.**



# Math Test – Calculator

55 MINUTES, 38 QUESTIONS

Turn to Section 4 of your answer sheet to answer the questions in this section.

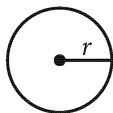
## DIRECTIONS

For questions 1-30, solve each problem, choose the best answer from the choices provided, and fill in the corresponding bubble on your answer sheet. For questions 31-38, solve the problem and enter your answer in the grid on the answer sheet. Please refer to the directions before question 31 on how to enter your answers in the grid. You may use any available space in your test booklet for scratch work.

## NOTES

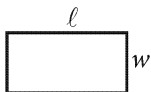
1. The use of a calculator **is permitted**.
2. All variables and expressions used represent real numbers unless otherwise indicated.
3. Figures provided in this test are drawn to scale unless otherwise indicated.
4. All figures lie in a plane unless otherwise indicated.
5. Unless otherwise indicated, the domain of a given function  $f$  is the set of all real numbers  $x$  for which  $f(x)$  is a real number.

## REFERENCE

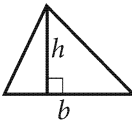


$$A = \pi r^2$$

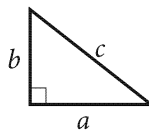
$$C = 2\pi r$$



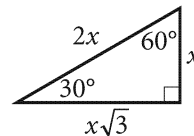
$$A = \ell w$$



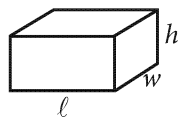
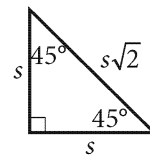
$$A = \frac{1}{2}bh$$



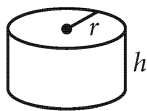
$$c^2 = a^2 + b^2$$



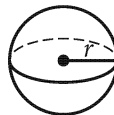
Special Right Triangles



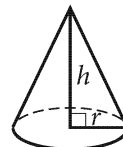
$$V = \ell wh$$



$$V = \pi r^2 h$$



$$V = \frac{4}{3}\pi r^3$$



$$V = \frac{1}{3}\pi r^2 h$$



$$V = \frac{1}{3}\ell wh$$

The number of degrees of arc in a circle is 360.

The number of radians of arc in a circle is  $2\pi$ .

The sum of the measures in degrees of the angles of a triangle is 180.



1

The function  $g$  is defined by  $g(x) = 5^x$ . What is the value of  $g(2)$ ?

- A) 52
- B) 32
- C) 25
- D) 10

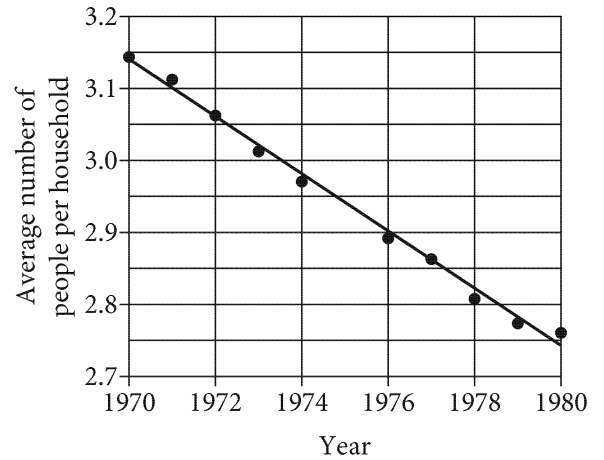
2

$$\begin{aligned}x + 2y &= 23 \\ 2y &= 15\end{aligned}$$

The solution to the given system of equations is  $(x, y)$ . What is the value of  $x$ ?

- A) -8
- B) -7
- C) 8
- D) 38

3



The scatterplot shows the average number of people per household in the United States for select years from 1970 to 1980. A line of best fit for the data is also shown. Which of the following is closest to the average number of people per household predicted by the line of best fit for 1976?

- A) 2.7
- B) 2.9
- C) 3.1
- D) 3.2



4

If  $4x + 4 = 20$ , what is the value of  $x + 1$  ?

- A) 4
- B) 5
- C) 6
- D) 9

5

| Grade | Number of students |
|-------|--------------------|
| 10    | 6                  |
| 11    | 18                 |
| 12    | 12                 |
| Total | 36                 |

The table shows the number of students in each grade in North High School's band. If a student is selected at random from the band, what is the probability that the student is in grade 12 ?

- A)  $\frac{1}{6}$
- B)  $\frac{1}{3}$
- C)  $\frac{1}{2}$
- D)  $\frac{2}{3}$

6

The total cortical surface area from the hemisphere of a certain primate brain is 2,261 square millimeters. There are 127,000,000 total neurons in this hemisphere. Which of the following is closest to the cortical neuron density, in neurons per square millimeter, for this hemisphere?

- A) 287,000
- B) 178,000
- C) 125,000
- D) 56,200





Questions 7 and 8 refer to the following information.

|                                     | Phobos | Deimos |
|-------------------------------------|--------|--------|
| Average diameter (kilometers)       | 22.2   | 12.4   |
| Orbital semimajor axis (kilometers) | 9,376  | 23,458 |
| Orbital period (hours)              | 7.56   | 30.30  |
| Average moonrise period (hours)     | 11.12  | 131    |

The planet Mars has two moons, Phobos and Deimos. The table shows the average diameter, orbital semimajor axis, orbital period, and average moonrise period for each moon.

7

Which of the following is closest to the number of Earth days for the average moonrise period of Deimos? (Use 1 Earth day = 24 hours.)

- A) 0.2
- B) 1.3
- C) 2.2
- D) 5.5

8

Which of the following is closest to the ratio of the orbital semimajor axis of Phobos to the orbital semimajor axis of Deimos?

- A) 1 to 5
- B) 1 to 4
- C) 2 to 5
- D) 3 to 4



Questions 9 and 10 refer to the following information.

The table summarizes data about a sample of adult female polar bears and their yearlings (cubs between 1 and 2 years of age). The data were collected as part of a study of polar bears in the southern Beaufort Sea.

| Age (years) | Number of adult females | Percent of adult females having yearlings |
|-------------|-------------------------|---|
| 5 to 9      | 36                      | 19%                                       |
| 10 to 14    | 26                      | 19%                                       |
| 15 to 19    | 8                       | 38%                                       |
| 20 or older | 10                      | 40%                                       |
| Total       | 80                      | 24%                                       |

9

What percentage of the adult females in the sample were 5 to 9 years old?

- A) 26%
- B) 31%
- C) 36%
- D) 45%

10

How many of the adult females aged 20 years or older had yearlings?

- A) 4
- B) 8
- C) 10
- D) 40

11

Yessenia is going to buy a car. The total amount she will pay for the car will include the selling price of the car, 6% sales tax on the selling price of the car, and \$426 for fees. If Yessenia wants to spend at least \$18,000 but no more than \$20,000, which of the following selling prices is within her budget?

- A) \$16,500
- B) \$17,500
- C) \$18,500
- D) \$19,500

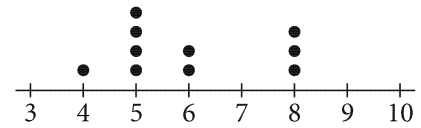


12

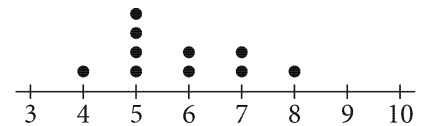
The ratio of 6 to  $x$  is equivalent to the ratio of 24 to  $y$ . Which equation represents  $y$  in terms of  $x$ ?

- A)  $y = \frac{1}{5}x$
- B)  $y = \frac{1}{4}x$
- C)  $y = 4x$
- D)  $y = 5x$

13



Data set A



Data set B

Which of the following statements best compares the means of the two data sets shown?

- A) The mean of data set A is less than the mean of data set B.
- B) The means of the two data sets are equal.
- C) The mean of data set A is greater than the mean of data set B.
- D) There is not enough information to compare the means of the two data sets.

14

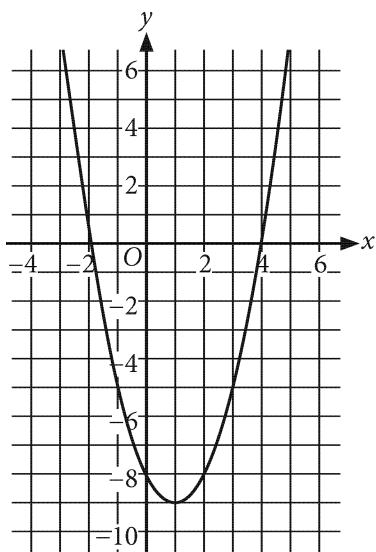
$$x^2 + 10x + 24 = 0$$

What is the sum of the solutions to the given equation?

- A)  $-24$
- B)  $-10$
- C)  $10$
- D)  $24$



15



What is an equation of the graph shown?

- A)  $y = (x + 1)^2 + 9$
- B)  $y = (x + 1)^2 - 9$
- C)  $y = (x - 1)^2 + 9$
- D)  $y = (x - 1)^2 - 9$

16

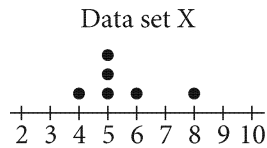
An educator conducted a survey about the use of social media in the classroom. A sample of 48 teachers was selected at random from all public high school teachers in City X. Each of the 48 teachers completed the survey, and 25% indicated that they use social media in the classroom. Which of the following is the largest population to which the results of this survey can be generalized?

- A) All public high school teachers in the country
- B) All teachers in City X
- C) All public high school teachers in City X
- D) All teachers in the sample



17

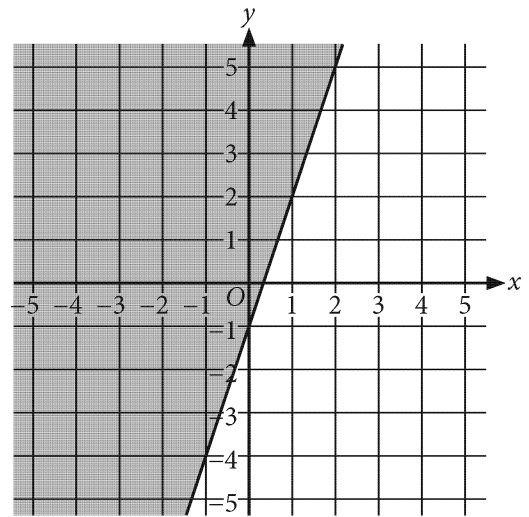
Data set X is represented by the dot plot shown.



Which dot plot represents a data set that has the same range as data set X?

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

18



The shaded region shown represents the solutions to which inequality?

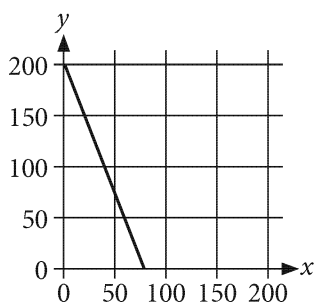
- A)  $y \leq 3x - 1$
- B)  $y \geq 3x - 1$
- C)  $y \leq -3x + 1$
- D)  $y \geq -3x + 1$



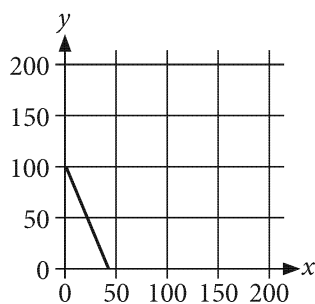
19

A small business will purchase thermoses and mugs to advertise the business. The thermoses cost \$5 each, the mugs cost \$2 each, and the business will spend \$200 on this purchase. The purchase can be modeled by the equation  $5x + 2y = 200$ , where  $x$  and  $y$  are the number of thermoses and mugs, respectively. Which graph represents this situation?

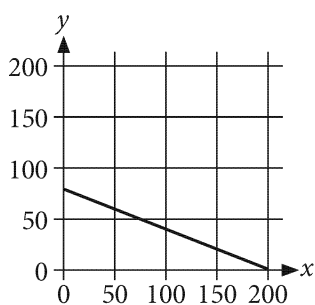
A)



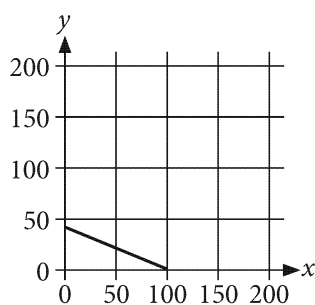
B)



C)

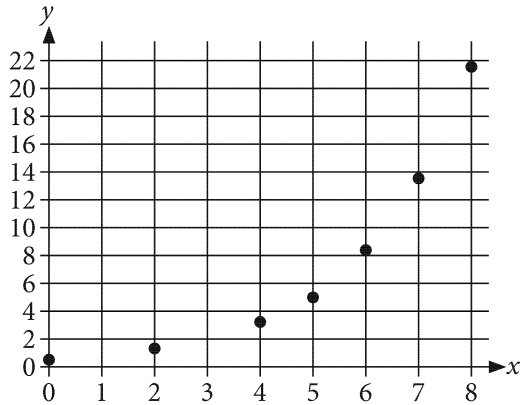


D)





20



Of the following, which best models the data in the scatterplot shown?

- A)  $y = 1.6(0.5)^x$
- B)  $y = 1.6(1.5)^x$
- C)  $y = 0.5(0.6)^x$
- D)  $y = 0.5(1.6)^x$

21

The surface area of a cube is 24 square meters. What is the volume, in cubic meters, of the cube?

- A) 4
- B) 8
- C) 64
- D) 144

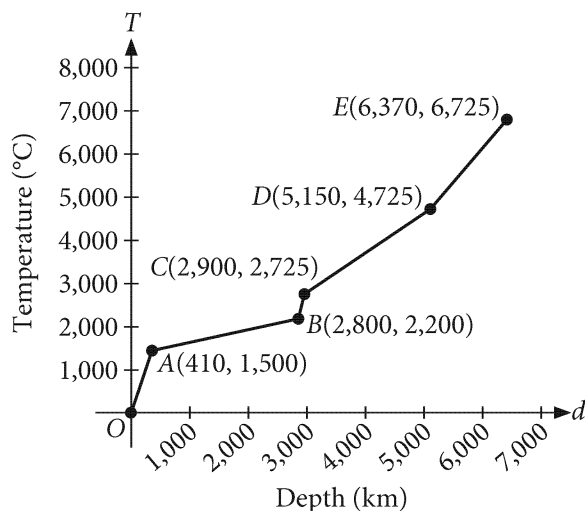
22

The graph of  $x^2 - 10x + y^2 + 6y - 5 = 0$  in the  $xy$ -plane is a circle. What point  $(x, y)$  is the center of this circle?

- A)  $(5, -3)$
- B)  $(10, -6)$
- C)  $(25, 9)$
- D)  $(100, 36)$



Questions 23 and 24 refer to the following information.



The graph shown models Earth's approximate internal temperature  $T$ , in degrees Celsius ( $^{\circ}\text{C}$ ), in terms of the depth  $d$ , in kilometers (km), below Earth's surface. The coordinates of five points on the graph are also shown.

23

Which statement is the best interpretation of point  $B$  in this context?

- A) The approximate internal temperature 2,800 km below Earth's surface is 2,200 $^{\circ}\text{C}$ .
- B) The approximate internal temperature 2,200 km below Earth's surface is 2,800 $^{\circ}\text{C}$ .
- C) From Earth's surface to 2,800 km below Earth's surface, the approximate internal temperature increases by 2,200 $^{\circ}\text{C}$  per kilometer of depth.
- D) From Earth's surface to 2,200 km below Earth's surface, the approximate internal temperature increases by 2,800 $^{\circ}\text{C}$  per kilometer of depth.

24

The layer of Earth's surface at a depth between 0 km and 410 km is sometimes called the lithosphere. Which equation best models the lithosphere's approximate internal temperature  $T$ , in degrees Celsius, as a function of the depth  $d$ , in kilometers?

- A)  $T = 410d + 1,500$
- B)  $T = 1,500d + 410$
- C)  $T = \frac{410}{1,500}d$
- D)  $T = \frac{1,500}{410}d$

25

$$\begin{aligned} -7x + 3y &= 3 \\ -17x + 8y &= 3 \end{aligned}$$

How many solutions does the given system of equations have?

- A) Zero
- B) Exactly one
- C) Exactly two
- D) Infinitely many





26

The variables  $x$  and  $y$  are related such that each time  $x$  increases by 3,  $y$  decreases by 4. If  $y = 8$  when  $x = 0$ , which of the following equations expresses the relationship between  $x$  and  $y$ ?

- A)  $3x - 4y = 8$
- B)  $3x - 4y = -32$
- C)  $3x + 4y = 32$
- D)  $4x + 3y = 24$

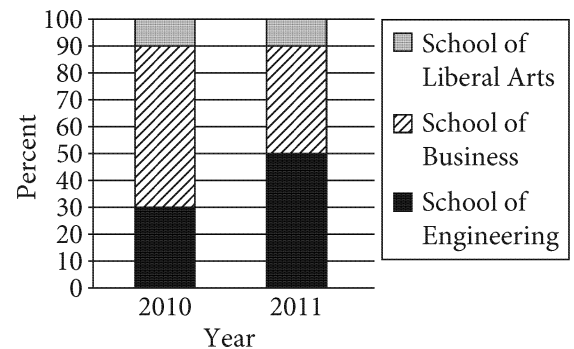
27

A model of how information spreads estimates that every  $\frac{1}{2}$  hour the number of people who have heard the information increases by 75%. Which equation represents this model when 30 people initially hear the information, where  $y$  is the approximate number of people who have heard the information  $x$  hours after the information is initially heard?

- A)  $y = 30(1.75)^{2x}$
- B)  $y = 30(1.75)^{\frac{x}{2}}$
- C)  $y = 75(1.5)^{2x}$
- D)  $y = 75(1.5)^{\frac{x}{2}}$

28

Distribution of Enrollment  
at a University by School  
in 2010 and 2011



The segmented bar graph above shows the distribution of students at a university by school in 2010 and 2011. There were 10,000 students enrolled at the university in 2010. If there were 3,000 more students enrolled at the School of Engineering in 2011 than in 2010, which of the following best approximates the increase in the total number of students enrolled at the university from 2010 to 2011?

- A) 2,000
- B) 3,000
- C) 4,000
- D) 5,000



29

Which quadratic equation has no real solutions?

- A)  $x^2 + 4x - 4 = 0$
- B)  $x^2 - 4x + 4 = 0$
- C)  $2x^2 - 4x - 4 = 0$
- D)  $2x^2 - 4x + 4 = 0$

30


Larry is training for a half marathon by going on a long run every Saturday. He will run 3 miles on the first Saturday of his training. Each Saturday after the first, he will run 2 more miles than he ran on the preceding Saturday. Which of the following equations represents the number of miles  $m$  Larry will run on the  $n$ th Saturday of his training?

- A)  $m = 2n + 3$
- B)  $m = 2n + 1$
- C)  $m = 2n - 1$
- D)  $m = 2^n + 3$


**DIRECTIONS**

For questions 31–38, solve the problem and enter your answer in the grid, as described below, on the answer sheet.

- Although not required, it is suggested that you write your answer in the boxes at the top of the columns to help you fill in the bubbles accurately. You will receive credit only if the bubbles are filled in correctly.
- Mark no more than one bubble in any column.
- No question has a negative answer.
- Some problems may have more than one correct answer. In such cases, grid only one answer.

- Mixed numbers** such as  $3\frac{1}{2}$  must be gridded as 3.5 or  $7/2$ . (If  is entered into the

grid, it will be interpreted as  $\frac{31}{2}$ , not  $3\frac{1}{2}$ .)

- Decimal answers:** If you obtain a decimal answer with more digits than the grid can accommodate, it may be either rounded or truncated, but it must fill the entire grid.

**Answer:  $\frac{7}{12}$**

Write answer in boxes. →

Grid in result. →

Fraction line ←

**Answer: 2.5**

Decimal point ←

|                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
| 7                     | /                     | 1                     | 2                     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 0                     | 0                     | 0                     | 0                     |
| 1                     | 1                     | 1                     | 1                     |
| 2                     | 2                     | 2                     | 2                     |
| 3                     | 3                     | 3                     | 3                     |
| 4                     | 4                     | 4                     | 4                     |
| 5                     | 5                     | 5                     | 5                     |
| 6                     | 6                     | 6                     | 6                     |
| 7                     | 7                     | 7                     | 7                     |
| 8                     | 8                     | 8                     | 8                     |
| 9                     | 9                     | 9                     | 9                     |

|                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
|                       | 2                     | .                     | 5                     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 0                     | 0                     | 0                     | 0                     |
| 1                     | 1                     | 1                     | 1                     |
| 2                     | 2                     | 2                     | 2                     |
| 3                     | 3                     | 3                     | 3                     |
| 4                     | 4                     | 4                     | 4                     |
| 5                     | 5                     | 5                     | 5                     |
| 6                     | 6                     | 6                     | 6                     |
| 7                     | 7                     | 7                     | 7                     |
| 8                     | 8                     | 8                     | 8                     |
| 9                     | 9                     | 9                     | 9                     |

Acceptable ways to grid  $\frac{2}{3}$  are:

|                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
|                       | 2                     | /                     | 3                     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 0                     | 0                     | 0                     | 0                     |
| 1                     | 1                     | 1                     | 1                     |
| 2                     | 2                     | 2                     | 2                     |
| 3                     | 3                     | 3                     | 3                     |
| 4                     | 4                     | 4                     | 4                     |
| 5                     | 5                     | 5                     | 5                     |
| 6                     | 6                     | 6                     | 6                     |
| 7                     | 7                     | 7                     | 7                     |
| 8                     | 8                     | 8                     | 8                     |
| 9                     | 9                     | 9                     | 9                     |

|                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
| .                     | 6                     | 6                     | 6                     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 0                     | 0                     | 0                     | 0                     |
| 1                     | 1                     | 1                     | 1                     |
| 2                     | 2                     | 2                     | 2                     |
| 3                     | 3                     | 3                     | 3                     |
| 4                     | 4                     | 4                     | 4                     |
| 5                     | 5                     | 5                     | 5                     |
| 6                     | 6                     | 6                     | 6                     |
| 7                     | 7                     | 7                     | 7                     |
| 8                     | 8                     | 8                     | 8                     |
| 9                     | 9                     | 9                     | 9                     |

|                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
| .                     | 6                     | 6                     | 7                     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 0                     | 0                     | 0                     | 0                     |
| 1                     | 1                     | 1                     | 1                     |
| 2                     | 2                     | 2                     | 2                     |
| 3                     | 3                     | 3                     | 3                     |
| 4                     | 4                     | 4                     | 4                     |
| 5                     | 5                     | 5                     | 5                     |
| 6                     | 6                     | 6                     | 6                     |
| 7                     | 7                     | 7                     | 7                     |
| 8                     | 8                     | 8                     | 8                     |
| 9                     | 9                     | 9                     | 9                     |

**Answer: 201 – either position is correct**

|                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
|                       | 2                     | 0                     | 1                     |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 0                     | 0                     | 0                     | 0                     |
| 1                     | 1                     | 1                     | 1                     |
| 2                     | 2                     | 2                     | 2                     |
| 3                     | 3                     | 3                     | 3                     |

|                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|
| 2                     | 0                     | 1                     |                       |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 0                     | 0                     | 0                     | 0                     |
| 1                     | 1                     | 1                     | 1                     |
| 2                     | 2                     | 2                     | 2                     |
| 3                     | 3                     | 3                     | 3                     |

**NOTE:**

You may start your answers in any column, space permitting. Columns you don't need to use should be left blank.



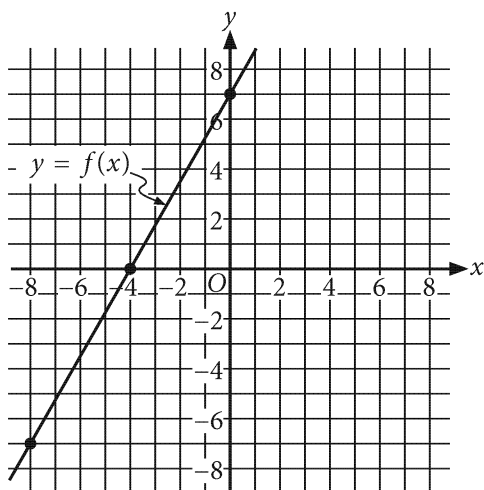
31

The entire senior class at a high school voted on the color for their class T-shirt. The results are shown in the table.

| Color  | Number of votes |
|--------|-----------------|
| Red    | 123             |
| Yellow | 210             |
| Blue   | 367             |
| Total  | 700             |

If a senior is selected at random, what is the probability of selecting a senior who voted for yellow? (Express your answer as a decimal or fraction, not as a percent.)

32



The graph of the linear function  $f$  is shown. The function can be written as  $f(x) = mx + b$ , where  $m$  and  $b$  are constants. What is the value of  $m$ ?

33

The expression  $\frac{x^6(x-3)}{2x} + \frac{3x^6}{2x}$  is equivalent to  $\frac{1}{2}x^c$ , where  $c$  is a constant and  $x > 0$ . What is the value of  $c$ ?

34

| Name    | Length |
|---------|--------|
| Nile    | 4160   |
| Congo   | 2720   |
| Niger   | 2600   |
| Zambezi | 1700   |
| Orange  | 1300   |
| Limpopo | 1100   |
| Kasai   | 1100   |
| Lualaba | 1100   |
| Cubango | 1000   |

The table shows the length, in miles, of 9 major rivers in Africa. What is the median length, in miles, of the 9 rivers?



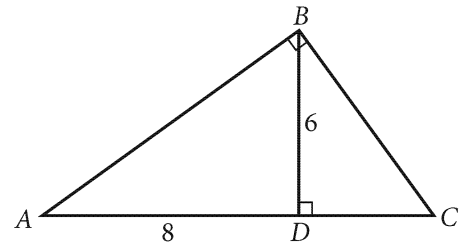
35

A dance studio had  $x$  students when it opened. One year later, the studio had  $1.2x$  students. If the number of students in the studio increased by  $p\%$  during this one-year period, what is the value of  $p$ ?

36

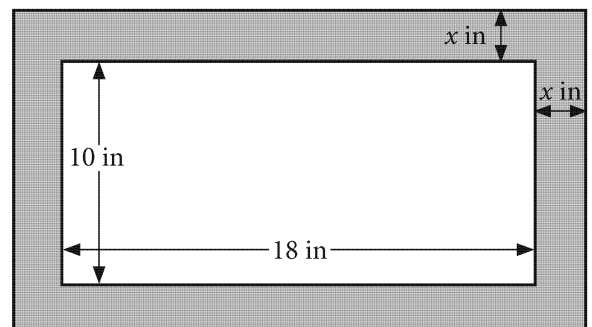
When Michael swims he burns 9 calories per minute and when he walks he burns 4 calories per minute. If Michael spends a total of 4 hours walking and swimming and burns a total of 1600 calories, how many minutes did he spend walking?

37



In the figure above,  $\triangle ABC$  and  $\triangle BCD$  are right triangles,  $AD = 8$ , and  $BD = 6$ . What is the length of  $\overline{DC}$ ?

38



A company manufactures picture frames. The figure shows a frame with a shaded border of width  $x$  inches (in) and inside dimensions of 10 in by 18 in. The area of the shaded border is 128 square in. What is the value of  $x$ ?

# STOP

**If you finish before time is called, you may check your work on this section only.  
Do not turn to any other section.**

# March 12, 2022 International

## ANSWER KEY

### Reading Test Answers

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

READING TEST  
RAW SCORE  
(NUMBER OF  
CORRECT ANSWERS)

### Writing and Language Test Answers

|      |      |      |      |
|------|------|------|------|
| 1 B  | 12 D | 23 B | 34 D |
| 2 A  | 13 C | 24 B | 35 A |
| 3 D  | 14 A | 25 C | 36 C |
| 4 A  | 15 C | 26 A | 37 A |
| 5 B  | 16 B | 27 B | 38 C |
| 6 C  | 17 B | 28 D | 39 C |
| 7 D  | 18 D | 29 A | 40 A |
| 8 B  | 19 B | 30 A | 41 C |
| 9 D  | 20 A | 31 C | 42 C |
| 10 C | 21 D | 32 C | 43 D |
| 11 B | 22 C | 33 B | 44 B |

WRITING AND  
LANGUAGE TEST  
RAW SCORE  
(NUMBER OF  
CORRECT ANSWERS)

### Math Test – No Calculator Answers

|      |                       |
|------|-----------------------|
| 1 A  | 11 D                  |
| 2 A  | 12 B                  |
| 3 C  | 13 A                  |
| 4 C  | 14 B                  |
| 5 B  | 15 C                  |
| 6 C  | 16 16                 |
| 7 C  | 17 $7/3$ , 2.33, 2.34 |
| 8 B  | 18 30                 |
| 9 D  | 19 7, 8, 9            |
| 10 A | 20 5                  |

MATH TEST –  
NO CALCULATOR  
RAW SCORE  
(NUMBER OF  
CORRECT ANSWERS)

### Math Test – Calculator Answers

|      |      |      |                 |
|------|------|------|-----------------|
| 1 C  | 11 B | 21 B | 31 .3, $3/10$   |
| 2 C  | 12 C | 22 A | 32 $7/4$ , 1.75 |
| 3 B  | 13 C | 23 A | 33 6            |
| 4 B  | 14 B | 24 D | 34 1300         |
| 5 B  | 15 D | 25 B | 35 20           |
| 6 D  | 16 C | 26 D | 36 112          |
| 7 D  | 17 C | 27 A | 37 $9/2$ , 4.5  |
| 8 C  | 18 B | 28 A | 38 2            |
| 9 D  | 19 B | 29 D |                 |
| 10 A | 20 D | 30 B |                 |

MATH TEST –  
CALCULATOR  
RAW SCORE  
(NUMBER OF  
CORRECT ANSWERS)