Extended Reading Comprehension:
Extraordinary Elements

Read the science passage. Then answer the questions that follow.

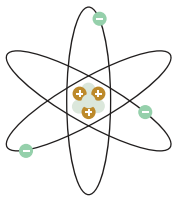
1 Earth, fire, water, and air: the ancient Greeks believed that these four elements were the basic building blocks of all matter. In science today, we still define **elements** as fundamental substances, but the elements are more numerous and quite different from the four described by ancient philosophers.

Modern Elements: An Elemental Overview

Atoms and Elements

Elements are made up of tiny particles called atoms, which in turn are made up of three tinier subatomic particles: protons, electrons, and neutrons. Individual elements are made up of all the same kind of atom. An element's atomic number is determined by the number of protons in the nucleus of each of its atoms. The known elements are listed in numerical order on the periodic table of elements according to their atomic number.

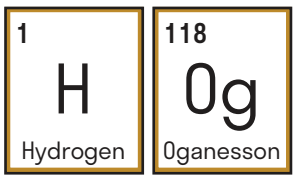
Atom structure



Electron Neutron
Proton Nucleus

Two Very Different Elements

The simplest, most abundant element in the universe is hydrogen. Each atom of this naturally occurring element has only one proton, so its atomic number is 1. It is the lightest of all the elements. The much heavier element oganesson has an atomic number of 118. Oganesson is a synthetic element, made by scientists in a high-tech machine called a particle accelerator. This machine creates high-speed collisions between atomic particles to help scientists study how the universe—and its elements—were created.



2 Each known element has specific properties. Those with similar properties are grouped together on the periodic table into categories. For example, there are particular types of metals and nonmetals and a special group of noble gases. These categories help scientists predict how elements will behave under certain conditions and react when combined with other elements. There is still much to learn about elements and their potential technological applications, but there is no doubt that many elements have properties that make them extraordinarily cool—in more ways than one!

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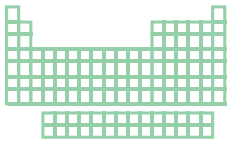
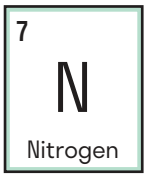


Nitrogen

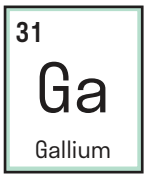


3 Nitrogen is a nonmetal with an atomic number of 7. Like all elements, it can exist as a solid, a liquid, or a gas, depending on temperature and atmospheric pressure. Under normal atmospheric conditions here on Earth, nitrogen is a colorless, odorless gas. It makes up 78 percent of the air we breathe. Nitrogen is essential for all life. That makes it an exceptionally "cool" element—as in *excellent* and *awesome*.

4 In its liquid and solid states, though, nitrogen is very, *very* cool—as in *brr!* Nitrogen condenses into a liquid between –346°F and –322°F, temperatures much lower than the coldest temperature ever recorded anywhere on Earth. Liquid nitrogen instantly freezes things that it comes into contact with. It is manufactured and used to flash freeze food products for transportation over long distances. Some ice cream shops even use liquid nitrogen to instantly make customized ice cream flavors on demand for their customers! (Now, *that's* definitely cool!)

5 Even colder than liquid nitrogen is solid nitrogen. Icy solid nitrogen covers the surface of Neptune's largest moon, Titan, one of the coldest known places in our solar system. Geysers on Titan spew liquid nitrogen that freezes on the moon's surface; some of the nitrogen evaporates, forming a thin atmosphere around this tiny, distant, and very cold moon.

Gallium



6 Gallium is a type of metal with an atomic number of 31. At around 77°F, a temperature you might enjoy on a nice spring day, gallium is a solid. A spoon made of gallium would appear like any other metal spoon. But if you were to pick up a gallium spoon and hold it for a moment, one of gallium's unique properties would soon become evident: the spoon would bend! That's because gallium's melting point—the point at which it becomes a liquid—is much lower than other metals. It can melt from just the warmth of your hand. Bending gallium spoons is a classic "mind-bending" trick of magicians.

7 However, gallium is not just for tricks. Even when it's solid, gallium can easily be shaped and cut. Gallium also has the largest liquid temperature range of any metal, melting at just above room temperature but not boiling until around 4,000°F! Gallium has yet another peculiar ability: it can be supercooled, or kept in its liquid state even below its freezing point. The properties of this soft, liquid-loving, nontoxic metal make it a great alternative to mercury, a more dangerous metal, in thermometers. Gallium is also used in applications ranging from electronics to solar panels to LED lights.

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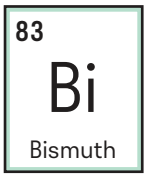
Bismuth

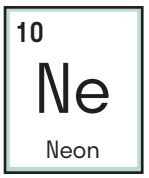


8 Bismuth is an element in the same group of metals as gallium. Bismuth's atomic number is 83, however, making it much heavier. In fact, it is nearly as heavy as another metal element, lead, but much less toxic, making it a viable replacement for lead in applications like water pipes. In its solid, natural state, bismuth is a lustrous, silvery-white metal with a slight pink tinge. But when bismuth is melted and then slowly cooled, it forms into colorful, iridescent crystals.

9 Another property bismuth shares with gallium is its relatively low melting point. Bismuth melts at around 520°F, a temperature easily reached on a stovetop. But bismuth conducts heat poorly; even when it's hot, things touching it stay cool. When mixed with other metals, bismuth transfers these properties to the resulting **alloys**, which are used in heat-defying applications, including fire detectors, fire extinguishing sprinklers, and molds for shaping hot materials. In these ways, bismuth really helps keep things cool.

10 One exceptionally interesting property of bismuth is its diamagnetism, or ability to repel magnets. Bismuth is the strongest known naturally occurring diamagnetic material. A magnet placed at just the right distance between two pieces of bismuth will levitate and stay suspended in the air between the two pieces, as if by magic. How cool is that?

Neon



11 Neon is in a group of colorless, odorless gases called the noble gases; its atomic number is 10. Neon may look "hot" when it's lighting up a neon sign with its orange-red glow, but in reality, neon really knows how to "keep its cool" in a crowd. Like all the noble gases, neon is nonreactive, or inert: it doesn't mix in with or get into a frenzy around other elements. However, when electricity is passed through this very stable gas at low pressures, neon looks like it's on fire! It's hard to miss, and that makes neon useful in lasers and high-voltage warning lights. Neon light can even cut through dense fog, so it's used for lighting aircraft and airports in cool and foggy regions.

12 Given the gas's fiery appearance, it's perhaps ironic that one of neon's other primary uses, in its liquid form, is as a coolant. Neon is a liquid at temperatures between –415°F and –410°F. Although it is expensive and hard to obtain—neon is rare on Earth and must be extracted from liquified air—it's an excellent and efficient refrigerant. Neon is used to keep expensive motorized equipment and electronics from overheating.

alloy: a metal made by melting and mixing two or more metals or a metal and another material

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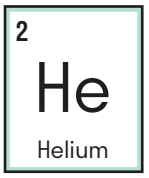
Helium

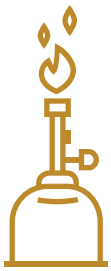


13 Like neon, helium is a noble gas. Its atomic number is 2, making it the second lightest element. Because helium weighs less than the surrounding air, balloons filled with helium float upward. But helium is not just for kids' party balloons. Airships called blimps rely on helium to give them shape and to fly. And the life-saving airbags in cars inflate so quickly because they are filled with helium.

14 When it comes to being cool, helium is the coolest—literally! Of all the elements, helium has the lowest melting and boiling points, –458°F and –452°F, respectively. This makes helium a valuable, stable coolant that is used in a multitude of applications; for example, it is used to cool the superconducting magnets in magnetic resonance imaging (MRI) machines, which allow physicians to look inside patients' bodies to detect and diagnose health conditions. Liquid helium also cools the particle accelerators that are used to create and discover new elements. Using helium this way may eventually allow the discovery of even more extraordinary elements.

15 Just as ancient philosophers tried to understand the natural world by defining the basic elements of matter and life, modern scientists look for answers by studying, experimenting with, and even creating new elements. The properties of these elements lend themselves to applications and new technologies that can improve our lives and help us understand the mysteries of the universe.

Answer the questions about "Extraordinary Elements."



1. **Part A: Which pair of adjectives best describes the overall tone of the passage?**

   A. solemn and formal
   B. grim and foreboding
   C. playful and informative
   D. urgent and intense

   Part B: Describe how the author's choice of words and content reflects this tone. Cite specific examples.

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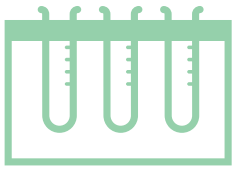

Keep going! Answer the questions about "Extraordinary Elements."

2. Part A: Based on the text, how do scientists distinguish one element from another?

A. by how many total atoms are needed to make a detectable whole

B. by the number of protons in the nucleus of each of its atoms

C. by its state of matter at standard temperature and pressure

D. by how tightly its atoms' subatomic particles are packed together

Part B: What text evidence supports this answer?

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3. Based on the text, how are gallium and bismuth similar? Choose two answers.

A. They are both nontoxic metals that can be used in place of more toxic elements.

B. They both form iridescent crystals when melted and then supercooled very quickly.

C. They are used in the same types of applications, including fire detectors and solar panels.

D. They both have melting points that are relatively low for metals.

E. They are both rare, diamagnetic elements that form alloys often used in magic tricks.

4. Part A: The author focuses on five different elements and links them together with a common theme relevant to their real-world properties and/or applications. What is the theme?

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Part B: Cite specific text evidence for each element to support your answer to Part A.

1. nitrogen: _____

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2. gallium: _____

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3. bismuth: _____

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4. neon: _____

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5. helium: _____

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Keep going! Answer the questions about "Extraordinary Elements."

5. **Part A: What is likely true about the periodic table of elements?**

A. With the discovery of the heaviest element, oganesson, it is finally complete.

B. It is likely to change as scientists learn more about and discover new elements.

C. It only includes elements that have been discovered in nature on Earth.

D. Along with the four Greek elements, it includes a total of 122 distinct elements.

Part B: Cite textual evidence from the passage to support this inference.

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2. _____

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6. **Describe how the author uses figurative language to explain the behavior of the element neon.**

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7. **Part A: Based on information in the text, what is likely true about nitrogen, neon, and helium?**

A. Their pure liquid states do not occur naturally on Earth.

B. They are all essential elements for human life on Earth.

C. They are all in the same group of gases on the periodic table.

D. They can be used interchangeably in most applications.

Part B: Summarize the textual evidence that supports your answer.

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8. **Read the following inference.**

> Elements with higher atomic numbers are generally heavier than elements with lower atomic numbers.

Cite one piece of text evidence that supports this inference.

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