2 Organizing the Elements

Reading Preview

Key Concepts

- How did Mendeleev discover the pattern that led to the periodic table?
- What data about elements are found in the periodic table?
- How is the organization of the periodic table useful for predicting the properties of elements?

Key Terms

- atomic mass
- periodic table
- chemical symbol
- period
- group

Target Reading Skill

Asking Questions Before you read, preview the red headings. In a graphic organizer like the one below, ask a *what* or *how* question for each heading. As you read, write the answers to your questions.

Patterns in the Elements

Question	Answer
What pattern of elements did Mendeleev discover?	Patterns appeared when . . .

Lab zone Discover Activity

Which Is Easier?

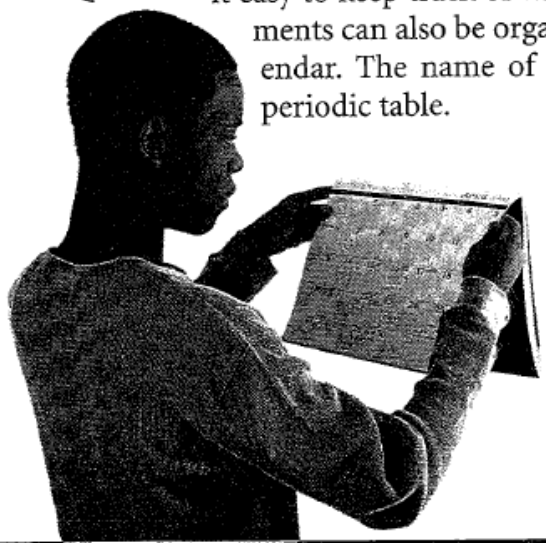
1. Make 4 sets of 10 paper squares, using a different color for each set. Number the squares in each set from 1 through 10.
2. Place all of the squares on a flat surface, numbered side up. Don't arrange them in order.
3. Ask your partner to name a square by color and number. Have your partner time how long it takes you to find this square.
4. Repeat Step 3 twice, choosing different squares each time. Calculate the average value of the three times.
5. Rearrange the squares into four rows, one for each color. Order the squares in each row from 1 to 10.
6. Repeat Step 3 three times. Calculate an average time.
7. Trade places with your partner and repeat Steps 2 through 6.

Think It Over

Inferring Which average time was shorter, the one produced in Step 4 or Step 6? Why do you think the times were different?

You wake up, jump out of bed, and start to get dressed for school. Then you ask yourself a question: Is there school today? To find out, you check the calendar. There's no school today because it's Saturday.

The calendar arranges the days of the month into horizontal periods called weeks and vertical groups called days of the week. This arrangement follows a repeating pattern that makes it easy to keep track of which day it is. The chemical elements can also be organized into something like a calendar. The name of the "chemists' calendar" is the periodic table.



◀ **A calendar organizes the days of the week into a useful, repeating pattern.**

Patterns in the Elements

By 1869, a total of 63 elements had been discovered. These elements had a wide variety of properties. A few were gases. Two were liquids. Most were solid metals. Some reacted explosively as they formed compounds. Others reacted more slowly. Scientists wondered if the properties of elements followed any sort of pattern. A Russian scientist, Dmitri Mendeleev (men duh LAY ef), discovered a set of patterns that applied to all the elements.

Mendeleev's Work Mendeleev knew that some elements have similar chemical and physical properties. For example, both fluorine and chlorine are gases that irritate the lungs and form similar compounds. Silver and copper, shown in Figure 5, are both shiny metals that tarnish if exposed to air. Mendeleev thought these similarities were important clues to a hidden pattern.

To try to find that pattern, Mendeleev wrote each element's melting point (M.P.), density, and color on individual cards. He also included the element's atomic mass and the number of chemical bonds it could form. The **atomic mass** of an element is the average mass of all the isotopes of that element. Mendeleev tried various arrangements of cards. **He noticed that a pattern of properties appeared when he arranged the elements in order of increasing atomic mass.**

Mendeleev's Periodic Table Mendeleev found that the properties of elements repeated. After fluorine (F), for instance, the next heaviest element he knew was sodium (Na). (Neon had not yet been discovered.) Sodium reacted with water the same way that lithium (Li) and potassium (K) did. So he placed the cards for these elements into a group. He did the same with other similar elements.

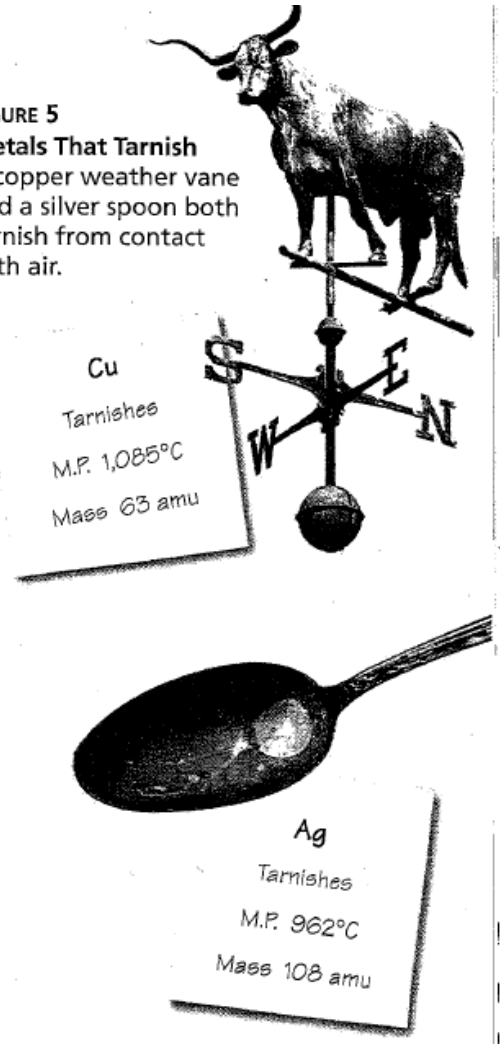


FIGURE 5
Metals That Tarnish
A copper weather vane and a silver spoon both tarnish from contact with air.

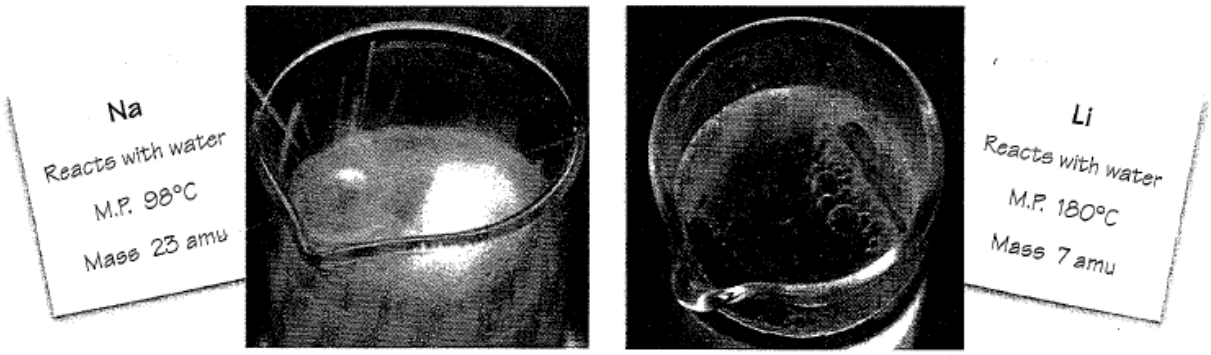


FIGURE 6
Metals That React With Water
Lithium and sodium both react with water. **Interpreting Photographs** *Which metal reacts more vigorously with water?*

FIGURE 7
Mendeleev's Periodic Table
When Mendeleev published his first periodic table, he left question marks in some places. Based on the properties and atomic masses of surrounding elements, he predicted that new elements with specific properties would be discovered.

			Ti=50	Zr=90	?=180.
			V=51	Nb=94	Ta=182.
			Cr=52	Mo=96	W=186.
			Mn=55	Rh=104,4	Pt=197,4
			Fe=56	Ru=104,4	Ir=198.
			Ni=Co=59	Pl=106,6	Os=199.
H=1			Cu=63,4	Ag=108	Hg=200.
	Be=9,4	Mg=24	Zn=65,2	Cd=112	
	B=11	Al=27,4	?=68	Ur=116	Au=197?
	C=12	Si=28	?=70	Sn=118	
	N=14	P=31	As=75	Sb=122	Bi=210
	O=16	S=32	Se=79,4	Te=128?	
	F=19	Cl=35,5	Br=80	I=127	
Li=7	Na=23	K=39	Rb=85,4	Cs=133	Tl=204
		Ca=40	Sr=87,6	Ba=137	Pb=207.
		?=45	Ce=92		
		?Er=56	La=94		
		?Yt=60	Di=95		
		?In=75,6	Th=118?		

Predicting New Elements Mendeleev found that arranging the known elements strictly by increasing atomic mass did not always group similar elements together. So, he moved a few of his element cards into groups where the elements did have similar properties. After arranging all 63 elements, three blank spaces were left. Mendeleev predicted that the blank spaces would be filled by elements that had not yet been discovered. He even predicted the properties of those new elements.

In 1869, Mendeleev published the first periodic table. It looked something like the one shown in Figure 7. Within 16 years, chemists discovered the three missing elements—scandium, gallium, and germanium. Their properties are close to those that Mendeleev had predicted.

The Modern Periodic Table In the **periodic table** used today, the properties of the elements repeat in each period—or row—of the table. (The word *periodic* means "in a regular, repeated pattern.") The periodic table has changed a little since Mendeleev's time. New elements were added as they were discovered. Also, an important change occurred in the early 1900s. In 1913, Henry Moseley, a British scientist, discovered a way to measure the positive charge on an atom's nucleus—in other words, the atomic number. Not long after, the table was rearranged in order of atomic number, not atomic mass. As a result, a few of the elements shifted position, and some of the patterns of properties became more regular. An up-to-date version of the table appears on pages 84 and 85.

Lab zone Skills Activity

Classifying

Choose any ten elements and assign them letters from *A* to *J*. On an index card for each element, write the letter for the element and list some of its properties. You may list properties that you learn about in this chapter or properties presented in another reference source.

Exchange cards with a classmate. Can you identify each element? Can you identify elements that have similar properties? Which properties are most helpful in identifying elements?

Questions from Reading

1.) Why is the periodic table like a calendar?

2.) How many elements had been discovered before Mendeleev discovered a pattern that applied to all elements?

3.) What kind of pattern did Mendeleev notice when he wrote down physical properties for each element?

4.) What is **atomic mass**?

5.) How did Mendeleev decide to place elements into groups?

6.) When Mendeleev arranged the Periodic Table by atomic mass, he noticed that _____

_____.
So instead, he grouped his elements by their _____. He noticed that there were _____ blank spaces where elements could go. In 1869, scientists discovered the three missing element, which were _____, _____ and _____ and their properties _____

_____.

7.) What does **periodic or period** mean?

8.) In 1913, what did Henry Moseley discover about the Periodic Table? How did it affect the way the Periodic Table was arranged?

9.) What is **atomic number**?

10.) What does **average atomic mass** mean? Explain.