

## Putting the Elements in Order

By 1864, chemists had identified 63 unique elements. To identify these elements, chemists described many of their chemical and physical properties. They grouped the elements according to these properties, just as you grouped some elements in the previous section. Antoine Lavoisier, a French scientist in the late 1700s, classified the known elements into four groups: metals, gases, non-metals, and “earths.” This classification was based on physical properties, such as electrical conductivity, lustre, and ductility. Other scientists had classified the elements by how they reacted with other elements. Neither classification, however, included all the elements.

### Ordering by Properties

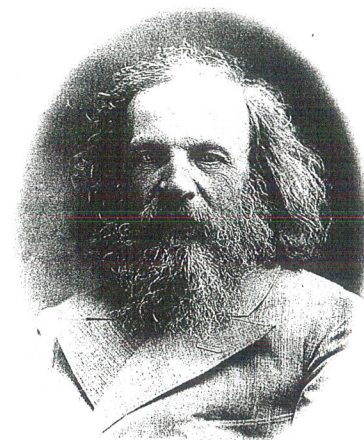
Working in the mid-1800s, a Russian scientist named Dmitri Mendeleev (Figure 1) tried to find a way of organizing all the elements to do more than just provide a listing of the known elements and their properties. At that time, it was known that each element had a specific and unique mass. Scientists such as John Dalton had discovered that the masses of the elements involved in chemical reactions are always in certain proportions. For example, two parts hydrogen and one part oxygen always combine to form water ( $\text{H}_2\text{O}$ ). When the reaction is complete with no hydrogen or oxygen left over, the mass of oxygen used is eight times the mass of hydrogen. This means that the mass of oxygen is 16 times the mass of hydrogen because there is one part oxygen to two parts hydrogen. By studying reactions, scientists could tell how heavy one element was in relation to another. When the elements were listed in order of increasing mass (from lightest to heaviest), Mendeleev noted that certain other properties seemed to repeat with a regular pattern, as shown in Figure 2.

H	Li	Be	B	C	N	O	F	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr
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**Figure 2** Mendeleev noted that elements with common properties appear at regular intervals when ordered by mass, like the low-density reactive metals highlighted (in red) above.

To order the elements, Mendeleev wrote the known elements on cards, and listed their properties. He laid out the cards like a game of solitaire, moving and grouping them in different ways. Eventually, he sorted out the cards in order of increasing mass, from left to right. When the properties of elements periodically repeated, he began a new row each time to create a Periodic Table of the Elements. This periodic table listed the elements in horizontal rows (periods), with masses increasing from left to right. It also formed vertical columns (groups) of elements with common properties.

#### 6A • Investigation



**Figure 1** Dmitri Mendeleev observed patterns that allowed him to organize the elements into groups.

#### LEARNING TIP

As you study Figure 2, explain to a partner how Mendeleev's Periodic Table of Elements simplified the complex world of chemical reactions.

#### 6A • Investigation

##### Creating a Periodic Table

To perform this investigation, turn to page 197.

In this investigation, you will create a periodic table using properties of hypothetical elements.





## 6.3

## CHECK YOUR Understanding

- Explain the process of classification.
  - Give an example from your everyday life of how things are classified.
  - Describe the advantages of classifying a collection of objects or materials.
- State the periodic law in your own words.
- Explain why the word "periodic" is used in the name of the table of the elements.
- Which property did Mendeleev primarily use to classify the elements?
- Why did Mendeleev leave gaps in his Periodic Table?
  - What did Mendeleev predict about the "undiscovered" elements in the gaps?
- Which elements, discovered in the late 1800s, matched closely with Mendeleev's predictions?
- Which was the first noble gas discovered on Earth?
  - Where is this gas found?
  - Why did Ramsay search for more noble gases?
  - Why did the elements argon, neon, krypton, xenon, and helium need their own, new group in the Periodic Table?
- What feature(s) of Mendeleev's table made it so useful and accepted by chemists?
- Name two undiscovered elements that Mendeleev predicted. Did the eventual discovery of these elements provide evidence for the concept of the Periodic Table? Explain your thinking.
- Refer to Mendeleev's Periodic Table on the right and compare it with the modern Periodic Table at the back of this book.
  - Which elements are no longer included in Group I?
  - Which element from Mendeleev's seventh column is now considered out of place?
- When Mendeleev had to make a choice between grouping based on mass or grouping by similar properties, which did he choose? Why do you think he made this choice?
- The quality of any model is how well it explains what happens in the world. How well did Mendeleev's table explain the chemistry of his time? Does it still have the power to explain? Why or why not?
- Was the Periodic Table invented by Mendeleev or discovered by him? Explain your thinking.
- The Periodic Table was welcomed by chemists because it organized and included all the known elements. Did the table explain why or how this organization occurred? Explain your thinking.
- Suggest three possible questions that Mendeleev may have asked when he was attempting to organize the elements.

Groups	I	II	III	IV	V	VI	VII	VIII
Formulas of Compound	$R_2O$	$RO$	$R_2O_3$	$RO_2$ $H_4R$	$R_2O_5$ $H_3R$	$RO_3$ $H_2R$	$R_2O_7$ $HR$	$RO_4$
1	H(1)							
2	Li(7)	Be(9.4)	B(11)	C(12)	N(14)	O(16)	F(19)	
3	Na(23)	Mg(24)	Al(27.3)	Si(28)	P(31)	S(32)	Cl(35.5)	
4	K(39)	Ca(40)	—(44)	Ti(48)	V(51)	Cr(52)	Mn(55)	Fe(56) Co(59) Ni(59) Cu(63)
5	[Cu(63)]	Zn(65)	—(68)	—(72)	As(75)	Se(78)	Br(80)	
6	Rb(85)	Sr(87)	?Yt(88)	Zr(90)	Nb(94)	Mo(96)	—(100)	Ru(104) Rh(104) Pd(105) Ag(108)
7	[Ag(108)]	Cd(112)	In(113)	Sn(118)	Sb(122)	Te(125)	I(127)	

Figure 6

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