

another noble gas, helium, He, had been discovered as a component of the sun, based on the emission spectrum of sunlight. In 1895, Ramsay showed that helium also exists on Earth.

In order to fit argon and helium into the periodic table, Ramsay proposed a new group. He placed this group between the groups now known as Group 17 (the fluorine family) and Group 1 (the lithium family). In 1898, Ramsay discovered two more noble gases to place in his new group, krypton, Kr, and xenon, Xe. The final noble gas, radon, Rn, was discovered in 1900 by the German scientist Friedrich Ernst Dorn.

The Lanthanides

The next step in the development of the periodic table was completed in the early 1900s. It was then that the puzzling chemistry of the lanthanides was finally understood. *The lanthanides are the 14 elements with atomic numbers from 58 (cerium, Ce) to 71 (lutetium, Lu).* Because these elements are so similar in chemical and physical properties, the process of separating and identifying them was a tedious task that required the effort of many chemists.

The Actinides

Another major step in the development of the periodic table was the discovery of the actinides. *The actinides are the 14 elements with atomic numbers from 90 (thorium, Th) to 103 (lawrencium, Lr).* The lanthanides and actinides belong in Periods 6 and 7, respectively, of the periodic table, between the elements of Groups 3 and 4. To save space, the lanthanides and actinides are usually set off below the main portion of the periodic table, as shown in **Figure 6** on pages 140–141.

Element and atomic number		Difference in atomic numbers
Group 18	He 2	8
	Ne 10	
	Ar 18	8
	Kr 36	18
	Xe 54	18
	Rn 86	32
Group 1	Li 3	8
	Na 11	
	K 19	8
	Rb 37	18
	Cs 55	18
	Fr 87	32

FIGURE 4 In each of Groups 1 and 18, the differences between the atomic numbers of successive elements are 8, 8, 18, 18, and 32, respectively. Groups 2 and 13–17 follow a similar pattern.

Periodicity

Periodicity with respect to atomic number can be observed in any group of elements in the periodic table. Consider the noble gases of Group 18. The first noble gas is helium, He. It has an atomic number of 2. The elements following helium in atomic number have completely different properties until the next noble gas, neon, Ne, which has an atomic number of 10, is reached. The remaining noble gases in order of increasing atomic number are argon (Ar, atomic number 18), krypton (Kr, atomic number 36), xenon (Xe, atomic number 54), and radon (Rn, atomic number 86). The differences in atomic number between successive noble gases are shown in **Figure 4**. Also shown in **Figure 4** are atomic-number differences between the elements of Group 1, which are all solid, silvery metals. As you can see, the differences in atomic number between the Group 1 metals follow the same pattern as the differences in atomic number between the noble gases.

Starting with the first member of Groups 13–17, a similar periodic pattern is repeated. The atomic number of each successive element is 8, 18, 18, and 32 higher than the atomic number of the element above it. In Section 2, you will see that the second mystery presented by Mendeleev's periodic table—the reason for periodicity—is explained by the arrangement of the electrons around the nucleus.