

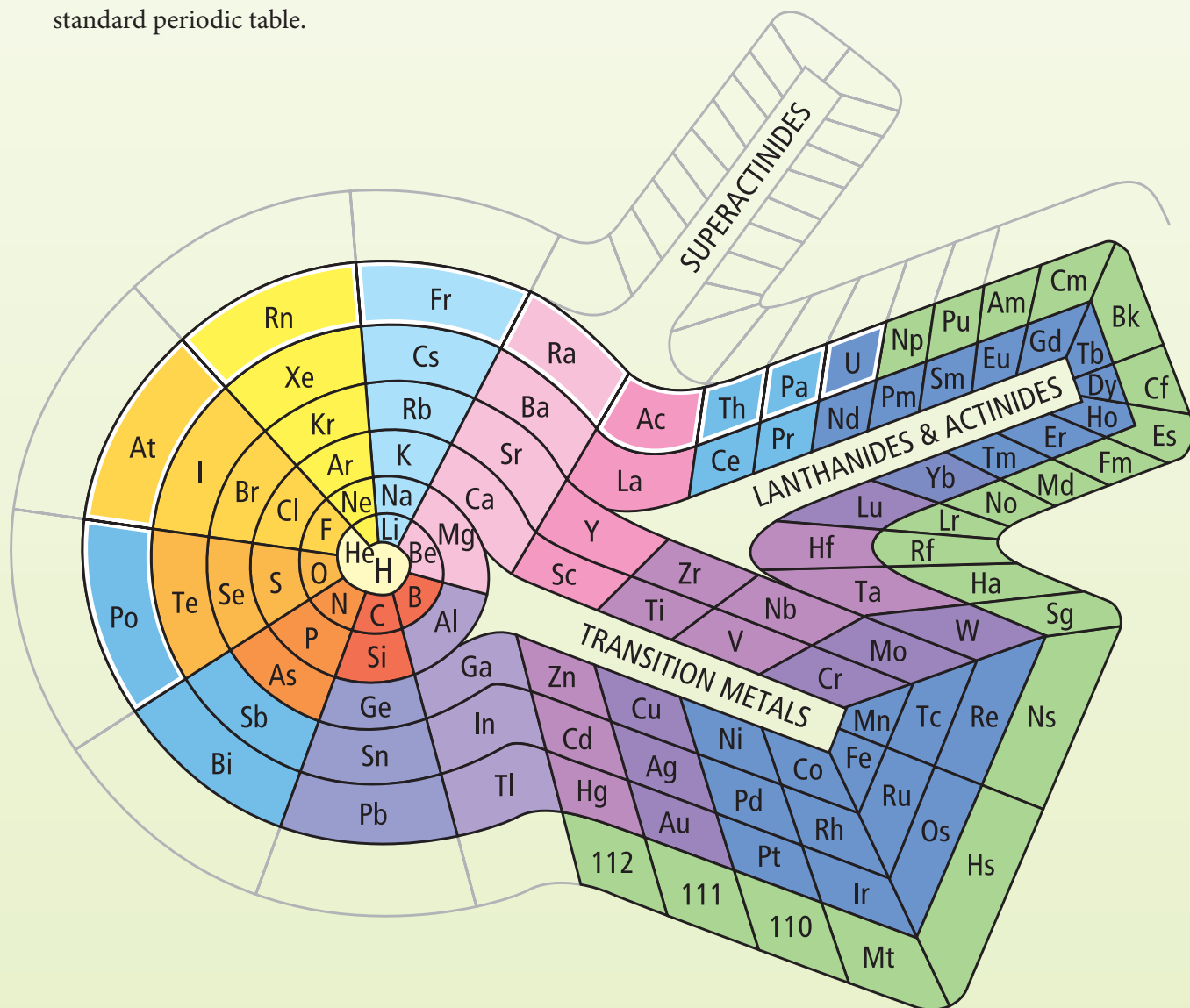
## 5.4 Trends in the Periodic Table

Think about all the things that change over time or in a predictable way. For example, the size of the computer has continually decreased over time. You may become more and more excited about a special event as it approaches. There is a definite trend in each of these examples because changes occur gradually at specific intervals. By analyzing the trends, you can make a fairly good prediction about the situation at a certain point in the future.

In a similar way, you can see trends in the properties of elements in the periodic table. As you look across a period or down a group, several properties of elements change in a regular way. The alternate periodic table, shown in **Figure 5.21** is based on a different trend analysis than the standard periodic table that you are used to seeing. The “arms” that stick out from the spiral are the lanthanides and actinides.

These are the elements that are in the two rows below the standard periodic table.

**Figure 5.21** You might not recognize this chart as a periodic table, but it is. The designer of this table used a spiral format to emphasize certain trends.



# Activity 5-7

## The Bohr-Rutherford Periodic Table

To help you understand the structure of the periodic table, you will apply the thinking skills you used in Activity 5-6 to examine the Bohr-Rutherford model cards you made in Investigation 5-A. Can you see any trends in the atomic structures of the first 20 elements?

### Materials

- 20 Bohr-Rutherford index cards, which you made in Investigation 5-A

### Procedure

1. Arrange the cards that you made in Investigation 5-A so that each Bohr-Rutherford diagram is face up on your desk. Examine each card. In what ways are the cards different? In what ways are they the same?
2. Arrange the cards into rows, so that all the cards in one row are the same in one way but different in another way. Then arrange the cards into columns, so that all the cards in one column are the same in one way but different in another way.
3. Keep moving the cards around until you are satisfied that you have the best possible table, with all the cards arranged in the most logical way.

4. Flip over each card, without moving the card to a different position, so that you can see the name and symbol on the card. Compare your arrangement of the cards with the arrangement of the elements in the periodic table.
5. If your cards do not match the periodic table, turn them over and repeat steps 2 to 4.
6. Once your cards match the periodic table, turn them over again so that you can use the Bohr-Rutherford models to answer the questions below.

### Questions

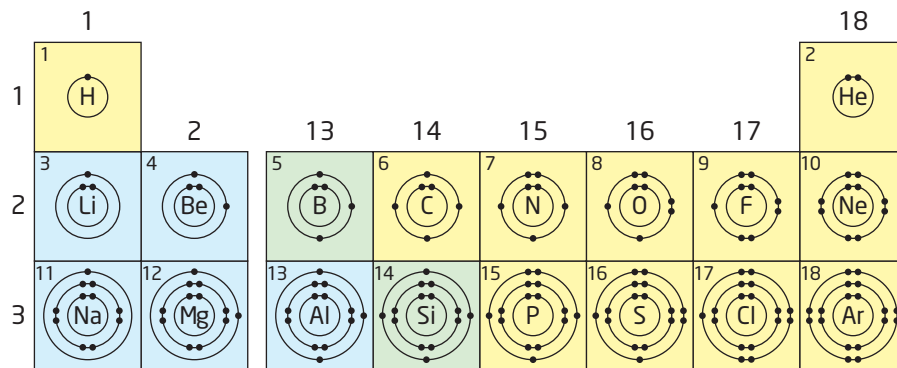
1. Examine Row 2. How are the Bohr-Rutherford models the same across the whole row? How are they different?
2. Examine Column 2. How are the Bohr-Rutherford models the same as you read down the column? How are they different?
3. What features of the Bohr-Rutherford models do not follow an exactly logical pattern?

## Reactivity and the Outermost Electrons

Many of the properties of elements are determined by the arrangement of the electrons in the outermost occupied energy level. Atoms within the same group in the periodic table have the same number of electrons in their outer energy level. As a result, elements in a group tend to react in a similar way. The electrons in the outermost occupied energy level of an atom are called **valence electrons**. **Figure 5.22**, on the next page, points out several important trends that occur in the arrangement of electrons in atoms.

**valence electron** an electron in the outermost occupied energy level of an atom

In the previous section, **Figure 5.20** highlighted differences among four groups of elements. For example, the elements in Group 18 (the noble gases) are non-reactive non-metals. In comparison, the elements in Group 17 (the halogens), which are just to the left of the noble gases, are the most reactive non-metals. The most reactive metals are in Group 1 (the alkali metals), which are immediately after the noble gases. Why are the reactivities of these elements different? The answer lies in the arrangement of the valence electrons in the atoms of these elements.



**Figure 5.22** Several patterns are visible in the electron arrangements in atoms of the first 18 elements.

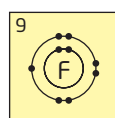
### Filling the Outer Energy Levels

During a chemical reaction, one atom can join with another atom by gaining, losing, or sharing valence electrons. (You will learn more about these changes in atoms in the next chapter.) The noble gases are non-reactive because their atoms do not gain, lose, or share electrons easily with other atoms. Helium atoms (with two valence electrons) and atoms of the other noble gases (with eight valence electrons) have the maximum number of electrons in their outermost occupied energy level. These atoms are said to have a full set of valence electrons, or a full outer energy level. Having a full outer energy level of electrons provides chemical stability, so these elements do not react easily with other elements.

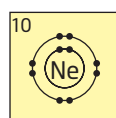
Atoms of elements other than the noble gases can achieve a full outer energy level, and therefore more stability, by gaining, losing, or sharing electrons. In general, the closer that an element is to the noble gases (either right or left) in the periodic table, the more reactive the element is. By looking at the models in **Figure 5.23** below, you can see why the elements in Groups 1 and 17 are very reactive, as shown in **Figure 5.24**. The atoms of these elements are only one electron away from having a full set of valence electrons. Atoms of the elements in Group 2 (alkaline-earth metals) must lose two electrons to have a full set of valence electrons. So, alkaline-earth metals tend to be less reactive than alkali metals.



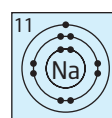
**Figure 5.24** As you can see in this photo, sodium is highly reactive with water.



Group 17:  
very reactive



Noble gas:  
non-reactive



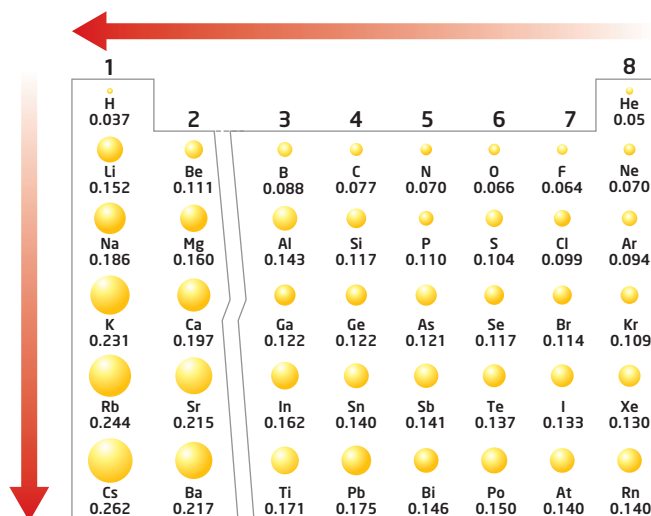
Group 1:  
very reactive

**Figure 5.23** The element to either side of a noble gas on the periodic table is very reactive. This is because they only need to lose or gain one electron to achieve the same electron arrangement as a noble gas atom.

## Reactivity and Atom Size

The distance from the centre of the nucleus to the outermost electrons determines the size of an atom. As you move down a group in the periodic table, the elements have valence electrons that occupy higher and higher energy levels. The higher the level is, the farther the valence electrons are from the nucleus and the larger the atom is. **Figure 5.25** shows this trend in atom size in the periodic table.

**Figure 5.25** Atomic size increases down a group and across a period, from right to left, in the periodic table. The number under each element symbol is the radius of the atom, in nanometers (nm). A nm is equal to  $10^{-9}$  m.



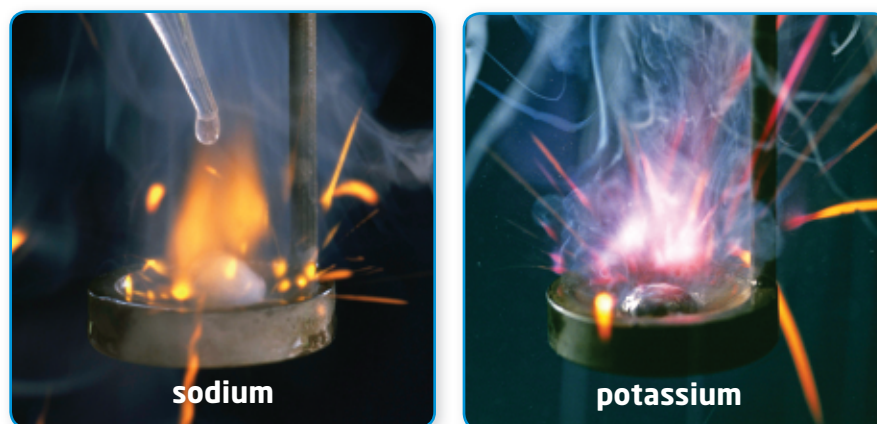
### Suggested Investigation

Inquiry Investigation 5-C,  
Reactivity Trends in the  
Periodic Table, on page 214

The farther the valence electrons are from the nucleus, the more easily they can be lost and, therefore, the more reactive the element is. For example, potassium has one valence electron in the fourth energy level, and sodium has one valence electron in the third energy level. A potassium atom loses its valence electron more easily than a sodium atom does, making it more reactive than sodium, as shown in **Figure 5.26**.

Atoms also generally get larger as you move from right to left across a period. All valence electrons for the atoms of elements in a period occupy the same energy level. The change in size results from decreased attraction between the valence electrons and the protons in the nucleus. As you move across a period, the energy levels remain constant but the number of protons decreases. The reduced pull of the electrons toward the nucleus causes an increase in atom size. Therefore, there is also an increase in reactivity of the metals across a period, going from right to left.

**Figure 5.26** A potassium atom loses its valence electron more easily than a sodium atom does, so potassium is more reactive than sodium.



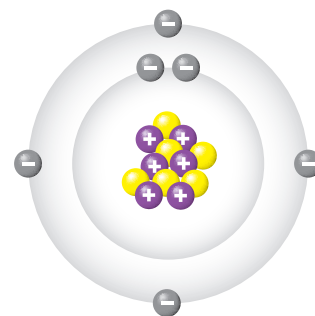
## Section 5.4 Review

### Section Summary

- There are trends, or regular changes, in the properties of the elements in the periodic table. The arrangement of the electrons in the atoms of the elements influences these trends in properties.
- The electrons in the outer energy level of an atom, called the valence electrons, help to determine many properties of the element. The number of valence electrons in an atom is the same for elements in a group but increases as you move across a period.
- The noble gases are non-reactive because they have a full set of valence electrons. The reactivity of other elements is based on their tendency to gain, lose, or share electrons to achieve a full set of valence electrons.
- The size of an atom increases as you move down a group in the periodic table. The size of an atom also increases as you move from right to left across a period in the periodic table.

### Review Questions

- T/I** 1. Draw a Bohr-Rutherford model of an atom with one valence electron.
- K/U** 2. Examine the diagram on the right. How many valence electrons does an element have that lies one position to the right on the periodic table from this atom?
- K/U** 3. Which has more valence electrons: an atom of aluminum or an atom of phosphorus?
- T/I** 4. Carbon is the basis of life as we know it. The four valence electrons in carbon atoms allow carbon to react with other elements to form a variety of compounds. What other element shares this property? Explain.
- K/U** 5. Explain why halogens are more reactive than noble gases.
- K/U** 6. What is the trend in the size of atoms as you move across a period? What is the trend as you move down a group?
- T/I** 7. Based on **Figure 5.25**, which is larger: an atom of oxygen or an atom of sulfur? Explain.
- T/I** 8. Which is more reactive: magnesium or calcium? Explain.
- C** 9. Describe a model that would help someone understand the trends in the sizes of atoms.
- K/U** 10. In the example of potassium and sodium, why is the larger atom more reactive? Explain.



The number of valence electrons in an atom indicates where the element is on the periodic table.