CONCEPT 4

Elements are classified as metals, non-metals, or semi-metals.

Activity

Comparing Conductivity

One property that is used to describe and classify matter is electrical conductivity. Materials that are electrical conductors allow electric current to move through them. Your teacher will give you an electrical conductivity meter and items to test. Make a table like the one below, and predict whether each item will conduct electric current. Then test your prediction. What do you notice about the materials that conduct electric current?

Item	Prediction	Is it a conductor?

The boxes on the periodic table in **Figure 2.9** are shaded to show the three broad categories of elements: metals (blue), non-metals (yellow), and semi-metals (green). These classifications are based on similarities in physical and chemical properties within each category. The elements of Groups 1, 2, and 13 to 18 are called *main-group elements* or *representative elements*. The elements in Groups 3 to 12 are called *transition elements*.

metal typically, an element that is hard, shiny, malleable, ductile, and that conducts electricity and heat; found to the left of the zigzag line on the periodic table

Metals

Most of the elements are metals. The **metals** are found on the left side of the zigzag line on the periodic table and are shaded in blue. Except for mercury, metals are solid at room temperature. They are shiny when smooth and clean, and most are silver or grey in colour. They are good conductors of thermal energy and electric current. They are also malleable and ductile, which means they can be beaten into sheets or drawn out into wires.

The two rows of metals shown at the bottom of the periodic table are called the *inner transition metals*. They are normally shown below the table to keep it compact. **Figure 2.12** shows two important groups of metals: the *alkali metals*, found in Group 1, and *alkaline-earth metals*, found in Group 2. Notice that although hydrogen is shown as part of Group 1, it is not an alkali metal. **Figure 2.13** explains why.

Activity

Predict Properties

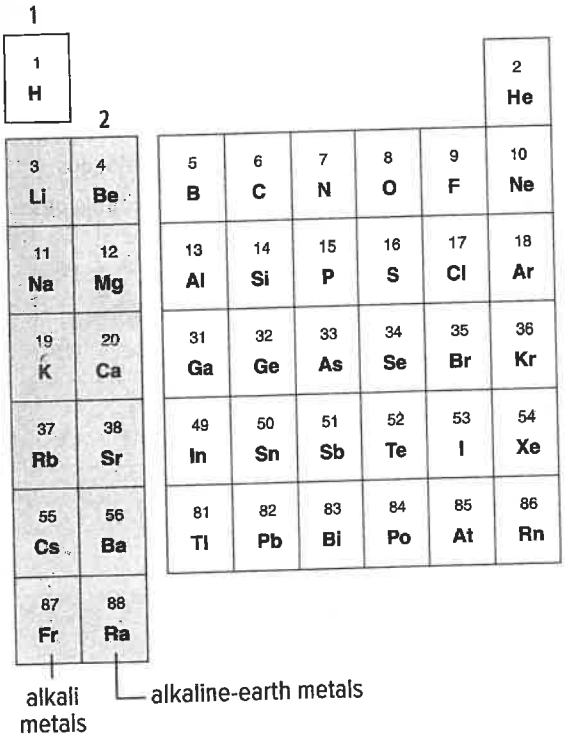
Francium is a rare, unstable alkali metal. It was discovered in 1939, but its existence was predicted by Mendeleev in the 1870s. Use data about the properties of other alkali metals to predict some of francium's properties.

Alkali Metals Data

Element	Melting Point (°C)	Boiling Point (°C)	Atomic radius (pm)
lithium	180.5	1342	152
sodium	97.8	883	186
potassium	63.4	759	227
rubidium	39.3	688	248
cesium	28.4	671	265
francium	?	?	?

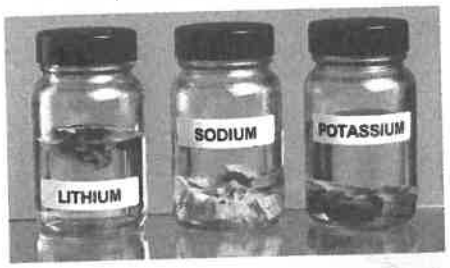
1. Come up with a way to clearly display the trends for each of the properties given in the table that will help you to predict a value for francium.
2. Predict whether francium is a solid, a liquid, or a gas at room temperature. How can you support your prediction?
3. Which of the following atomic radii is most likely to belong to francium: 252 pm, 270 pm, or 283 pm? Explain your prediction.

Figure 2.12 This periodic table has been cropped to show only the main-group elements. **What are some differences and similarities between the alkali metals and the alkaline-earth metals?**



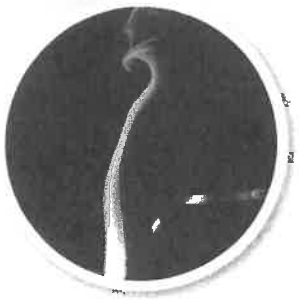
Alkali Metals

The elements of Group 1, except for hydrogen, are known as the alkali metals. They are shiny and soft—soft enough to be cut easily with a butter knife. Alkali metals are highly reactive with many substances, including water and oxygen. This reactivity is why pure alkali metals are stored in a non-reactive liquid such as kerosene or oil.



Alkaline-earth Metals

All of the elements of Group 2 are alkaline-earth metals. They are shiny and soft, but not as soft as the alkali metals. Alkaline-earth metals are also highly reactive, but not as reactive as the alkali metals. For example, magnesium does not need to be stored in a non-reactive liquid, but it burns easily in air when ignited, as shown here.



Non-metals

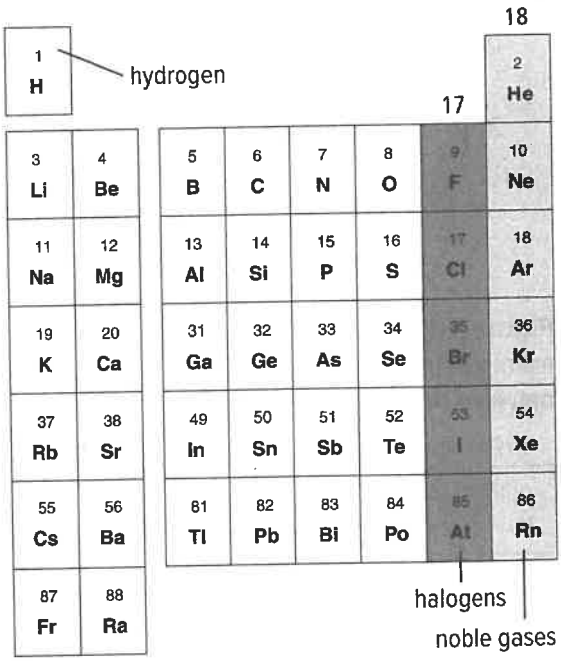
non-metal typically, an element that is not shiny, malleable, or ductile, and is a poor conductor of electric current and heat; found to the right of the zigzag line on the periodic table

The **non-metals** are found on the upper right side of the periodic table. Hydrogen, which is found in the upper left, is also a non-metal. In the periodic table in **Figure 2.9**, the nonmetals are shaded in yellow. Non-metals are elements that are generally gases or brittle, dull-looking solids. They are poor conductors of heat and electric current. **Figure 2.13** shows hydrogen as well as two important groups of non-metals: the *halogens* and the *noble gases*.

Figure 2.13 Halogens, the Group 17 elements, are highly reactive. The defining characteristic of noble gases, the Group 18 elements, is that they are unreactive.

Hydrogen: A Special Case

Hydrogen is usually placed on the left side of the periodic table. However, hydrogen is a non-metal, not a metal. The lightest element, hydrogen is a colourless, odourless, tasteless, and highly flammable gas. Hydrogen makes up over 90 percent of the atoms in the universe. On Earth, most hydrogen is found combined with oxygen as part of the compound water.

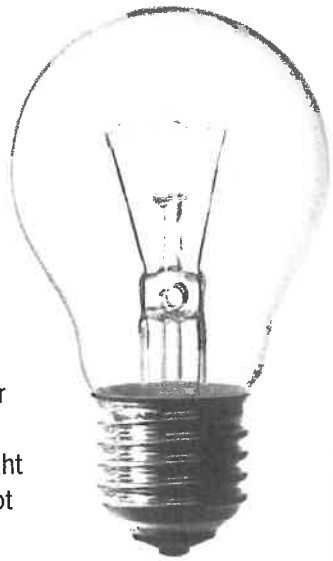


Halogens

The halogens are the elements of Group 17. These non-metals are highly reactive, which means they are usually found in nature as part of compounds. Bromine, shown here, is the only non-metal element that is a liquid at room temperature.

Noble Gases

The noble gases are the elements of Group 18. They are all odourless, colourless gases. They are the least reactive of all of the elements. Helium and neon never form compounds, and the other noble gases form compounds only with great difficulty. Incandescent light bulbs are filled with argon because the argon does not react with the tungsten filament in the bulb.



Semi-metals

The elements in the green boxes in a staircase shape are called the **semi-metals** or *metalloids*. Semi-metals are the in-between elements—they have physical and chemical properties of both metals and non-metals. For example, like metals, they are shiny solids at room temperature. But semi-metals are brittle and not ductile like non-metals. They also tend to be poor conductors of heat and electric current. **Figure 2.14** shows some important applications of semi-metals.

semi-metal an element that shares some properties with metals and some properties with non-metals

Extending the Connections

What makes silicon special?

Silicon is so important to the electronics industry that an area near San Francisco that has become a hub of this industry is nicknamed "silicon valley." What properties make silicon so important in the manufacture of electronics? Can other semi-metals be used in similar ways? Research to find out.

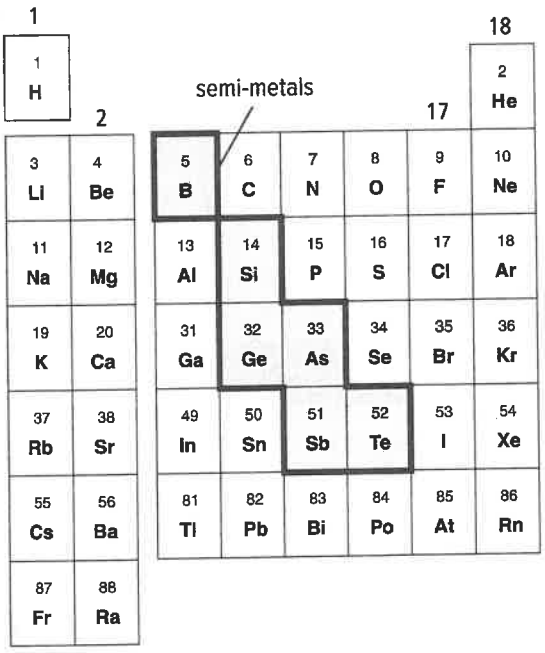
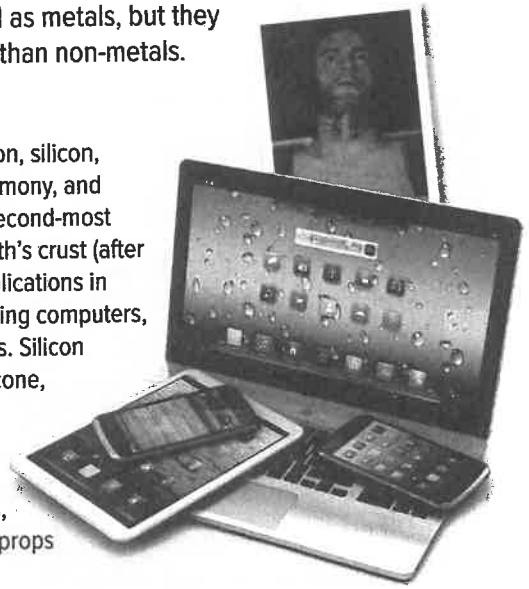


Figure 2.14 Semi-metals have some metallic properties and some non-metallic properties. Some of their properties are in-between. For example, semi-metals do not conduct electric current as well as metals, but they are better conductors than non-metals.



Semi-metals

The semi-metals are boron, silicon, germanium, arsenic, antimony, and tellurium. Silicon is the second-most abundant element in Earth's crust (after oxygen). It has many applications in electronic devices including computers, tablets, and smartphones. Silicon is also used to make silicone, which is part of a huge variety of applications, including car grease, cookware, satellite parts, contact lenses, and film props and prosthetics.

Before you leave this page . . .

1. Make a table to summarize the characteristic properties of metals, non-metals, and semi-metals.
2. What makes hydrogen an unusual element?
3. What characteristics define semi-metals?