From Charcoal to Diamonds

6.8

What do charcoal, a pencil, and a diamond ring have in common (Figure 1)? They are not alike in appearance and certainly quite different in price. Charcoal briquettes are black and opaque, crumble easily, and burn readily. Pencil "lead" is soft enough to leave a trail of black writing when it is gently pressed onto paper. White diamonds are colourless and transparent, sparkle brilliantly, and rank at the top of the hardness scale—and the price scale!

Figure 1 Charcoal, pencil "lead," and diamonds are all made of carbon atoms.

Surprisingly, all three of these substances are mostly made of atoms of exactly the same element: carbon. They differ only in how the carbon atoms are arranged. That difference accounts for their individual properties.

Charcoal

Unlike most other elements, carbon atoms can join with other carbon atoms almost indefinitely, forming unending structures. When this happens, a shapeless, disorganized arrangement of atoms is formed, creating a soft black solid—like the charcoal briquettes that we use in our barbecues. Charcoal consists of up to 98 % carbon mixed with ash and other chemicals.

Graphite

Graphite has an organized structure compared to charcoal. Each carbon atom in graphite joins with three other carbon atoms to form a sheet of interconnected hexagons. A carbon atom is located at each corner of the hexagon. These flat sheets are loosely layered on top of each other (Figure 2). This form of carbon is called graphite. Pencil "lead" is actually graphite. Under slight pressure, the carbon sheets slide across each other, leaving behind the top layer of carbon atoms on the surface of the writing paper. Pencil lead is more accurately named "pencil graphite mixed with clay." The carbon structure of graphite also makes it a good conductor, which is an unusual property for non-metals.

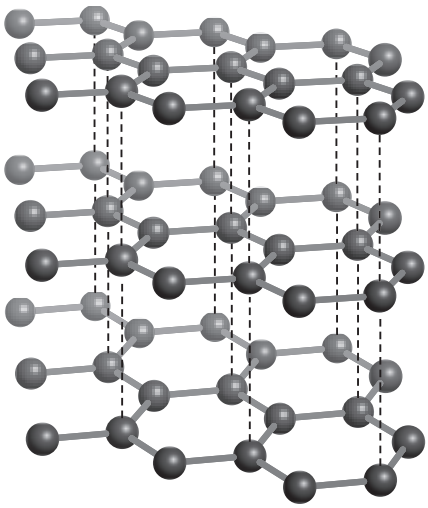

Figure 2 Graphite consists of sheets of carbon atoms.

TRY THIS COPPER-PLATE YOUR PENCIL

SKILLS: Performing, Observing, Analyzing, Communicating

SKILLS HANDBOOK 1., 3.B.6.

In this activity, you will coat the tip of a pencil with copper. The method you will use is called electroplating—using electrical energy to plate a metal onto a surface. Many beautiful objects, such as silver trays and gold jewellery, are electroplated. An electric current has to run through the object being plated, so the object must be able to conduct electricity.

Equipment and Materials: **eye protection; apron; 9 V battery; medium-sized beaker; graduated cylinder; 2 electrical wires; 2 pencils with both ends sharpened (for example, golf pencils); copper(II) sulfate solution**

Copper(II) sulfate solution is a skin and eye irritant. Wear eye protection and a lab apron.

1. Put on your apron and eye protection.
2. Dissolve approximately 5 mL of copper(II) sulfate in 50 mL of water in the beaker.
3. Sharpen both ends of each pencil and connect the electrical wires to one end of each pencil.
4. Connect the electrical wires to the two terminals of the 9 V battery.
5. Complete the circuit by placing the free tips of the pencils into the copper(II) sulfate solution so that the two pencil tips do not touch (Figure 3). Make sure that the wire connectors are above the solution. Secure the wires to the sides of the beaker.
6. After several minutes, disconnect the wires from the battery and remove the pencils from the solution. Rinse the pencils gently in water and observe the pencil tips.
7. Follow your teacher's instructions for the disposal of the materials and equipment.

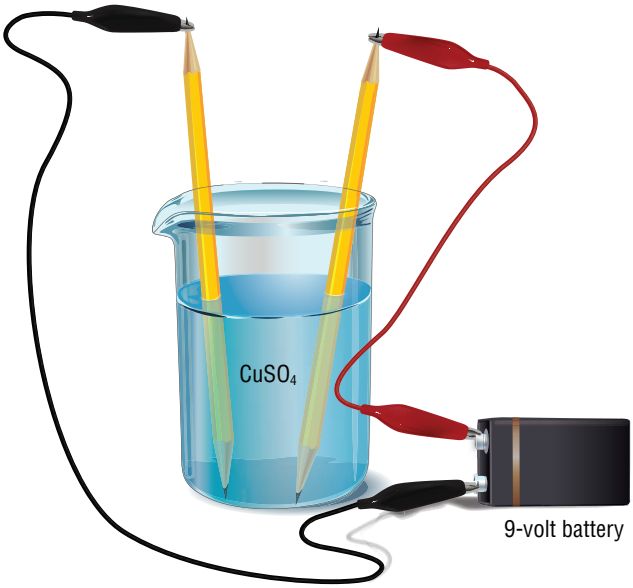

Figure 3 Copper-plating a pencil

8. Wash your hands thoroughly with soap and water.

A. What did you observe at the pencil tips while there was current in the circuit? T/I

B. Was there any evidence of copper being plated onto a pencil tip? T/I

C. Where did the copper come from in this experiment? T/I

D. What evidence was there to suggest that there was electrical current in the pencil graphite? T/I

E. Is graphite a metal or a non-metal? Explain your answer. T/I

F. Suggest some applications of graphite that make use of its properties. A

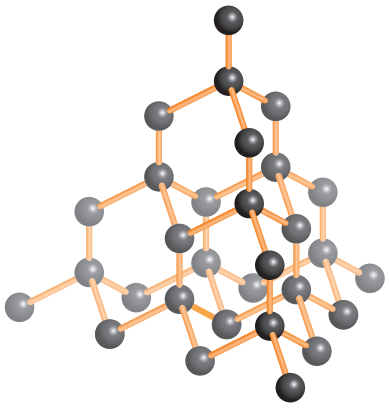

Figure 4 In diamond, each carbon atom is tightly bound to the carbon atoms surrounding it, which accounts for the hardness of diamond.

Diamond

Under conditions of extremely high temperature and pressure, carbon atoms arrange themselves into regular patterns that are interconnected in three dimensions. These patterns are similar to a playground climbing frame that never ends. This strongly reinforced framework is what gives diamond its remarkable hardness (Figure 4). The closeness of the atoms makes diamond very dense and also allows it to bend light, producing its much-admired sparkle when diamond is cut. This three-dimensional structure does not allow the free flow of electrons, so diamonds do not conduct electricity.

RESEARCH THIS ARTIFICIAL DIAMONDS

SKILLS: Researching, Analyzing the Issue, Communicating, Evaluating

SKILLS HANDBOOK 4.A., 4.B.

We usually think of diamonds as jewellery. However, diamonds are also useful in industry because of their hardness. The diamonds used in industry are usually artificial diamonds. In this activity, you will research and report on the industrial use of diamonds. You will also research artificial diamonds and the processes by which they are created.

1. What types of industries use diamond tools? T/I A
2. What kinds of processes require the use of diamond tools? T/I A
3. How are artificial diamonds manufactured? T/I
4. What are the main applications of artificial diamonds? T/I A
5. How are artificial diamonds different from natural diamonds? T/I

GO TO NELSON SCIENCE

A. Artificial diamonds have been available since the 1960s. Should diamond mining be phased out? Give reasons for your answer. A C
B. List the advantages and disadvantages of artificial diamonds. A
C. If you were buying diamond jewellery, would you rather buy real or artificial diamonds? Give reasons for your answer. A C

Diamond Rush in Canada

In the late 19th century, a gold rush brought tens of thousands of people to the Yukon in search of fortune. Today, mining companies dig for diamonds. Diamonds were first discovered in the Northwest Territories in the 1980s. Since then, Canada has become one of the top three diamond producers in the world (Figure 5). More than ten million carats of Canadian diamonds are produced each year in mines in the Northwest Territories, Nunavut, and Northern Ontario. That is over 15 % of the world's supply!

To learn more about career opportunities in diamond mining in Canada,
GO TO NELSON SCIENCE

Figure 5 The Diavik Diamond Mine on Lac de Gras, Northwest Territories

The diamond rush has benefited the Canadian North in many ways. However, any form of mining disturbs the environment. Layers of topsoil must be removed and carefully replaced to minimize the impact of excavating the land. In the Canadian Arctic, where ecosystems are particularly fragile, strong partnerships between the government and mining companies ensure that strict regulations are closely followed. Compared to gold mining, which uses cyanide, diamond mining has a far smaller environmental imprint. However, it is not without consequences. Diamond mining in Canada's North has resulted in lake drainage and stream destruction. Fish habitat has been lost and water quality has been changed, in some cases irreversibly. Permafrost recovers very slowly, if ever, from damage.

To learn more about becoming an environmental assessment professional,
GO TO NELSON SCIENCE

READING TIP

Revise Your Inferences

Sometimes you come across information that conflicts with an inference you have already made. For example, you read that diamond mining creates jobs in Canada and conclude that diamond mining is beneficial. However, after you read about the impact of diamond mining on the cost of living, you may change your opinion.

Diamond mining has societal consequences, which are more difficult to measure. Big profits bring business and highly paid jobs in the diamond industry as well as in construction and transportation. The demand for workers in Yellowknife and Iqaluit has left many jobs unfilled in neighbouring towns and cities. The cost of living has skyrocketed, caused in part by the cost of housing. Limited availability of housing has driven rents to unaffordable levels.

Unlike diamonds mined in parts of Africa, Canadian diamonds are much less controversial. They are not "blood diamonds," the name attached to mining operations that finance war and terror. Canadian diamonds are sold with a certificate that guarantees their source. They are promoted as "conflict free" certified. Each stone is etched with a tiny polar bear trademark (Figure 6).

Figure 6 Each Canadian diamond is etched with a tiny polar bear as a trademark.

IN SUMMARY

- Charcoal, graphite, and diamond are all made of carbon atoms. The carbon atoms are arranged differently in each substance, which accounts for their different properties.
- Diamond mining in Canada's North has brought economic benefits but has raised social and environmental concerns.

CHECK YOUR LEARNING

1. Describe how carbon atoms are joined together in charcoal, graphite, and diamond. K/U
2. Explain how a pencil makes a mark in terms of the arrangement of carbon atoms in graphite. K/U
3. What are some of the economic benefits of diamond mining in Canada's North? A
4. What are some of the environmental drawbacks of diamond mining in Canada's North? A
5. What properties of diamonds make them useful in a variety of applications? K/U
6. Explain which form of carbon is best suited for the following functions: A
   (a) an electrode in a battery
   (b) the tip on a drill bit for drilling through rocks
   (c) fuel in power plants