LESSON 7

Just a Phase

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How are heat and phase change involved in powering this old locomotive?

INTRODUCTION

Do you eat spaghetti? To cook spaghetti, you fill a large pot with water, perhaps add some salt, put the pot on the stove, and turn on the heat. When the water boils, you add the spaghetti, stir it well, and simmer for about 8 minutes. Why do you need to cook it for 8 minutes? What happens if you are in a hurry and want to cook it faster? Look at Figure 7.1 on page 65. Will "turning up the heat" raise the temperature and make the spaghetti cook faster? Does the boiling water get hotter the longer it boils? Why don't the cooking instructions tell you to cook the spaghetti as quickly as you can?

You may be surprised to learn that a lot of interesting science takes place when you heat water. In this lesson, you will look at and think about what happens when solid water, or ice, is heated until it boils and beyond.

OBJECTIVES FOR THIS LESSON

Discuss your current knowledge of phase change.

Observe what happens to ice as it is heated.

Measure the temperature of ice water as it is heated.

Plot a graph of your measurements.

Interpret your graph and other observations.

Figure 7.1 *Can you make simmering spaghetti cook faster by turning up the heat?*

Getting Started

1. After reading the Introduction, discuss the following questions with other members of your group:

   A. How could you make spaghetti cook faster?

   B. Why does ice melt?

   C. Why can you play in the snow when it is warm outside?

   D. Why doesn't ice melt immediately when you add it to a soft drink?

   E. Are things that are boiling always hot? Are things that are frozen always cold?

   F. What are some of your own questions about what happens when ice melts and water boils?

2. Record your group's and your own ideas in your science notebook. You will be asked to present some of these ideas during a short brainstorming session.

MATERIALS FOR LESSON 7

For you

1 copy of Student Sheet 7.1: Heating Ice Water

For your group

1 burner
1 burner stand or tripod and wire gauze
1 thermometer
1 250-mL beaker
3–4 ice cubes (or crushed ice)
Access to a clock or watch with a second hand

Inquiry 7.1
Heating Ice Water

PROCEDURE

1. Your teacher will explain how you should heat some ice. Watch and listen carefully.

2. Your teacher will allocate a heating station to your group. Decide which job each member of your group will do: One of you will measure the temperature, one will monitor the time, and two will record the temperature and make observations.

3. Carefully read the instructions below (A through L) and the Safety Tips.

A. Go to your heating station.

B. Check the apparatus against the materials list.

C. Pour cold tap water, to a depth of 1 cm, into the bottom of the beaker.

D. Collect three or four ice cubes. If the ice is crushed, get enough to fill the beaker to a depth of about 3 cm.

E. Place the thermometer in the ice water and allow it to stand for a few minutes.

F. Ask your teacher to light your burner. (If it is a Bunsen burner, adjust the flame so it is about 5 cm high.) Do not start heating the ice water yet.

G. Make sure your apparatus is set up as shown in Figure 7.2.

H. Measure the temperature of the ice water (by this time, some of your ice will have melted). Record the temperature next to time 0 in Table 1 on Student Sheet 7.1.

I. Put the beaker on the burner stand (see Figure 7.3). Slide the stand gently over the burner. Do not adjust the flame of your burner while you are heating the ice. Immediately start measuring the time.

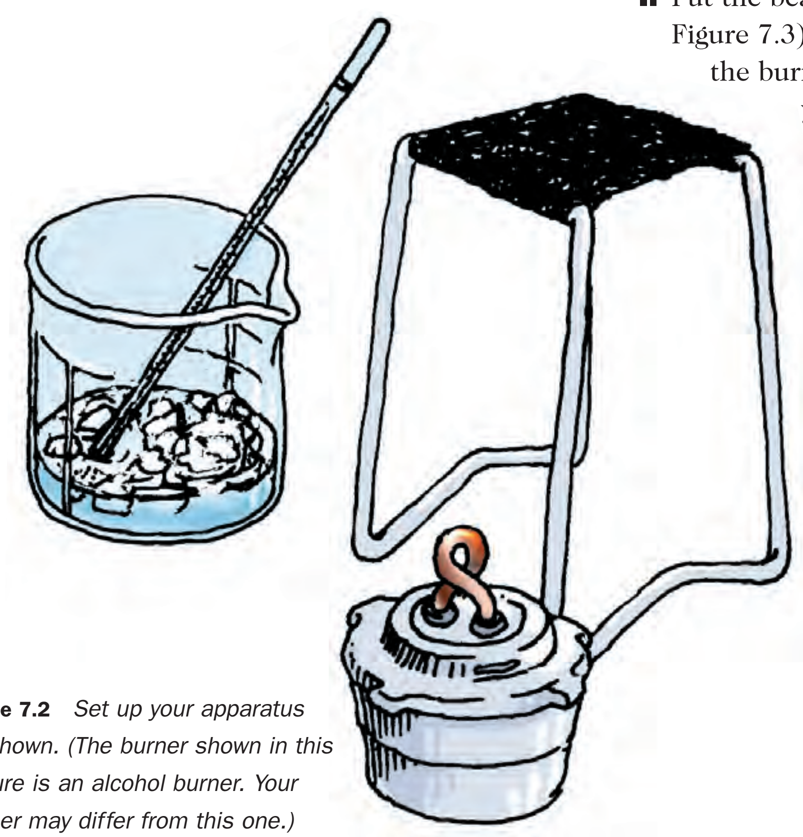

Figure 7.2 *Set up your apparatus as shown. (The burner shown in this picture is an alcohol burner. Your burner may differ from this one.)*

SAFETY TIPS

Tie back long hair.

Wear safety goggles throughout the inquiry.

Be careful when you handle hot apparatus.

Figure 7.3 *Heat the ice as shown. Measure and record the temperature every 30 seconds.*

J. Take the temperature every 30 seconds and record it. Observe any changes that take place and record these observations in Table 1.

K. When the water boils, continue to take readings for 3 minutes more.

L. Extinguish the burner and allow the apparatus to cool.

4. Follow Steps A through L.

5. When you finish, return to your place and make sure all members of your group have a complete copy of all the results and observations. Use this opportunity to discuss the observations you made with the other members of your group.

6. If your apparatus has cooled, pour out the water and clean up as instructed by your teacher.

7. Plot your data on the graph paper on Student Sheet 7.1. Give your graph a title. Decide which of the axes you will use for time and which for temperature. Remember: The independent variable goes on the horizontal (x) axis. If you are unsure what to do, discuss with your teacher how to lay out your graph. Make sure you accurately plot all of the points before you connect them to draw a curve. Label the curve to show where important changes took place (for example, "All the ice melted").

REFLECTING ON WHAT YOU'VE DONE

1. Discuss the following questions with the other members of your group:

A. How does the shape of your curve compare to those produced by other groups?

B. Do any changes in the direction of your curve match the point at which the ice melted or the water boiled?

C. How can you use the curve on your graph to determine the temperature at which ice melted and water boiled? Are these temperatures what you expect?

2. Record these melting and boiling points on your graph.

3. You will have the opportunity to discuss your ideas with the rest of the class.

4. Do Step 3 on Student Sheet 7.1: Make a copy of the diagram drawn by your teacher and label it and write a paragraph in your own words that *explains* the shape of the curve on your graph.

BOILING OIL

HISTORIC VU/VISUALS UNLIMITED

This old Texas gusher shows crude oil, under pressure from surrounding gas, being forced up from under the ground. Once out of the ground, the oil must be processed.

The next time you visit a gas station, look at some of the products sold there. In addition to gasoline, you'll probably find diesel fuel, kerosene, engine oil, gear grease, and other lubricants. All of these substances help keep cars and other vehicles running. Where do they come from?

A car's ability to cruise down the highway—and possibly even the highway itself—is based on the activity of a variety of organisms that lived in the sea hundreds of millions of years ago. These organisms died, but they only partially decomposed. Over millions of years, their remains became compressed, were heated, and eventually turned into crude oil and natural gas. By drilling down into the rocks where the crude oil and gas are found, it is possible to extract it.

Crude oil is very thick, comes in a variety of unusual colors (including red), and smells pretty awful. How is crude oil made into substances that can be used in cars? When crude oil is boiled, a lot of interesting things happen. You see, crude oil is not a single substance. It's a mixture.

As crude oil is heated, some of the substances in it start to boil. Substances with low boiling points, like gasoline, are the first to boil. Kerosene is next, followed by fuel oils (some of which are used to make diesel fuel) and then

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All of these different oils (or fractions) were obtained from crude oil by the process of fractional distillation. Each fraction has a different boiling point.


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Crude oil is separated into its different components in fractionating and cracking towers like these in Saudi Arabia.


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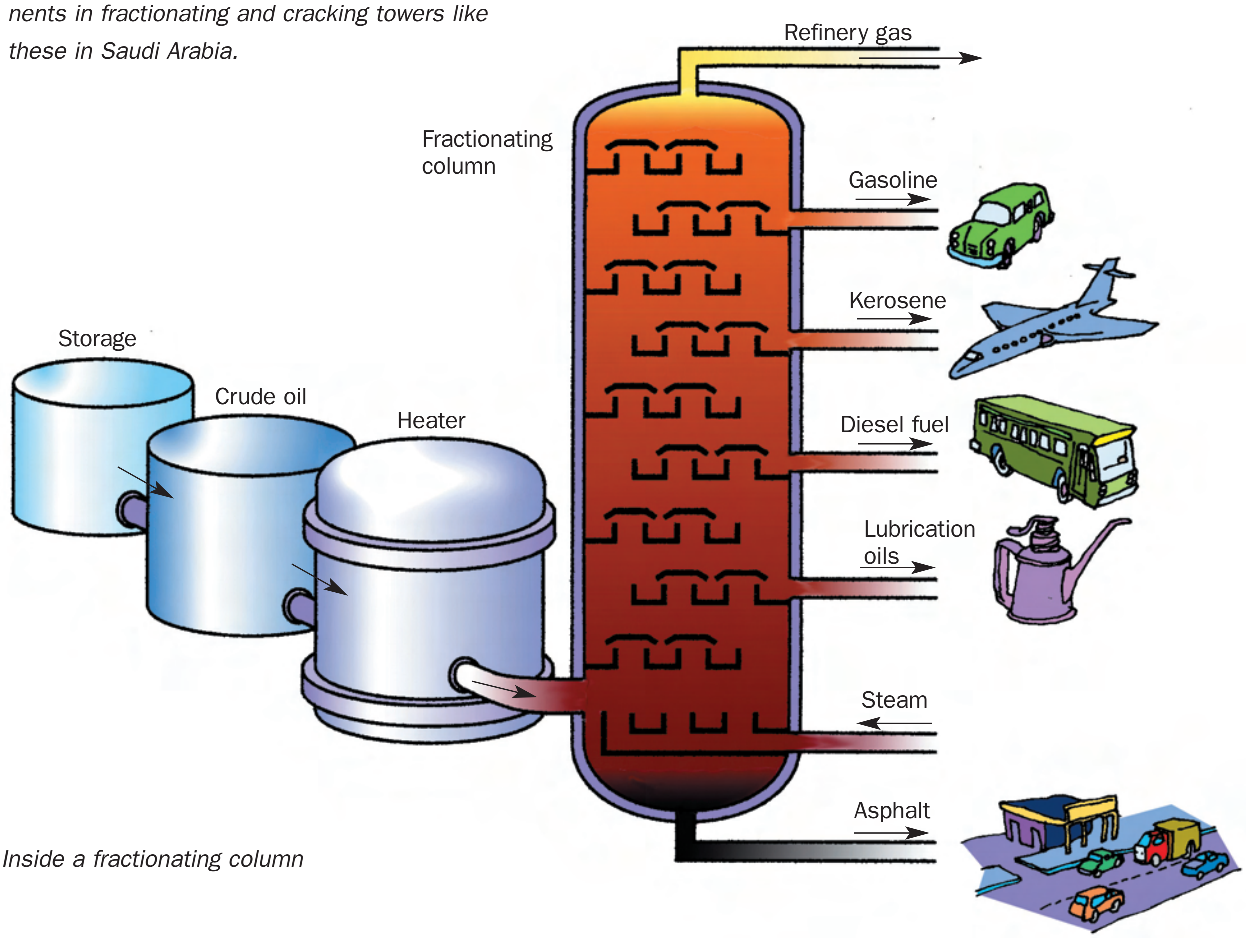
Oil is a very valuable resource, and people go to great lengths to extract it.

heavier oils (which are often used for lubrication). In the end, only the substances with high boiling points (more than 370 °C) are left—as a dark, gooey, smelly mess. But even these materials have a use. They make up asphalt, which is used as a surface for the highways on which cars travel!



Inside a fractionating column

All this boiling takes place at an oil refinery. The crude oil is heated in special towers called fractionating towers or columns. In different levels of the towers, gases produced when the crude oil is heated are condensed. The substances that come from crude oil are not only used to make fuels and lubricants. They are also used as raw materials for hundreds of industrial processes—from making glues to plastic bottles and even clothing. □

QUESTION

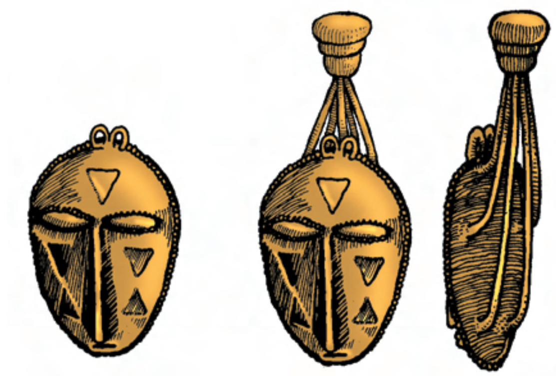
Examine this picture. How many of the items in it, including car parts, could be made from oil?

How many objects in this picture could be made from oil?

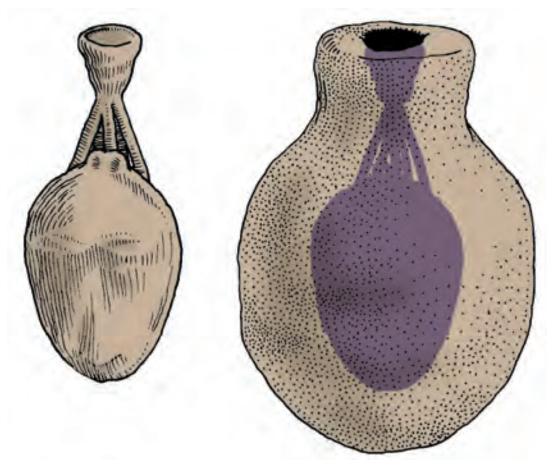
LOST WAX CASTING:
Exploiting Melting Points for Art and Industry

Knowledge of melting points is very important for people who work with metal. Let's look at the goldsmiths who live in a small village in Côte d'Ivoire (Ivory Coast), West Africa, as an example. They make jewelry and other items by using a technique that has been in existence for thousands of years. It is called "lost wax casting."

In this technique, an artist produces a clay mold around an easily carved substance: wax. When the mold is heated,



The artist carves a model in wax (usually beeswax). Wax is soft, and the artist can use it to produce intricate carvings. After completing the model, he attaches tiny wax rods (called sprues) to it that will produce channels in the mold for draining the wax and receiving the gold.



The artist covers the wax figure with several layers of fine wet clay. Coarse clay is then added in layers to complete the mold. The clay mold is placed in an oven and heated until it hardens. The wax melts and runs out of the mold (in other words, it's lost!).

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The wax model is carefully cleaned before the first layer of fine clay is added.

the wax, which has a melting point less than 70 °C, melts away. The hard clay mold can then be used to produce jewelry made from metals with high melting points. The artists often use gold, which has a melting point of more than 1000 °C.

The pictures here show the major steps in lost wax casting. In these pictures the artist is using gold. ☐

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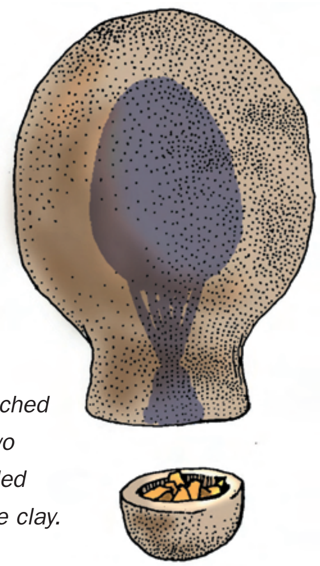
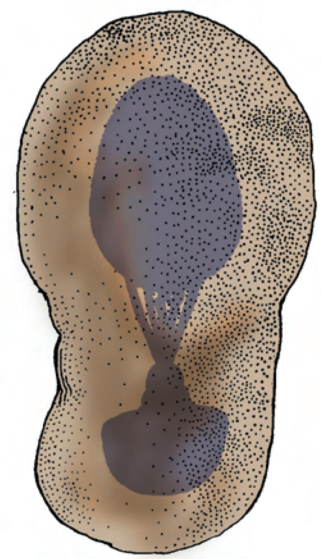
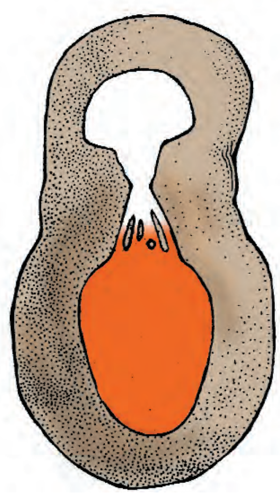
Air is pumped by hand bellows into a charcoal furnace. This produces the high temperature needed to melt gold.

Pieces of gold are placed in a crucible.





The crucible is attached to the mold. The two parts are then sealed together using more clay.



The mold and gold are heated together in the furnace. When the gold has melted, the mold is turned over so that the metal flows into it. The mold cools. The clay mold is cracked off, leaving a casting.

The artist files away a few rough edges, and the jewelry is ready.

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The lost wax method has been used to produce a wide variety of objects, including this figure of a king from Nigeria.

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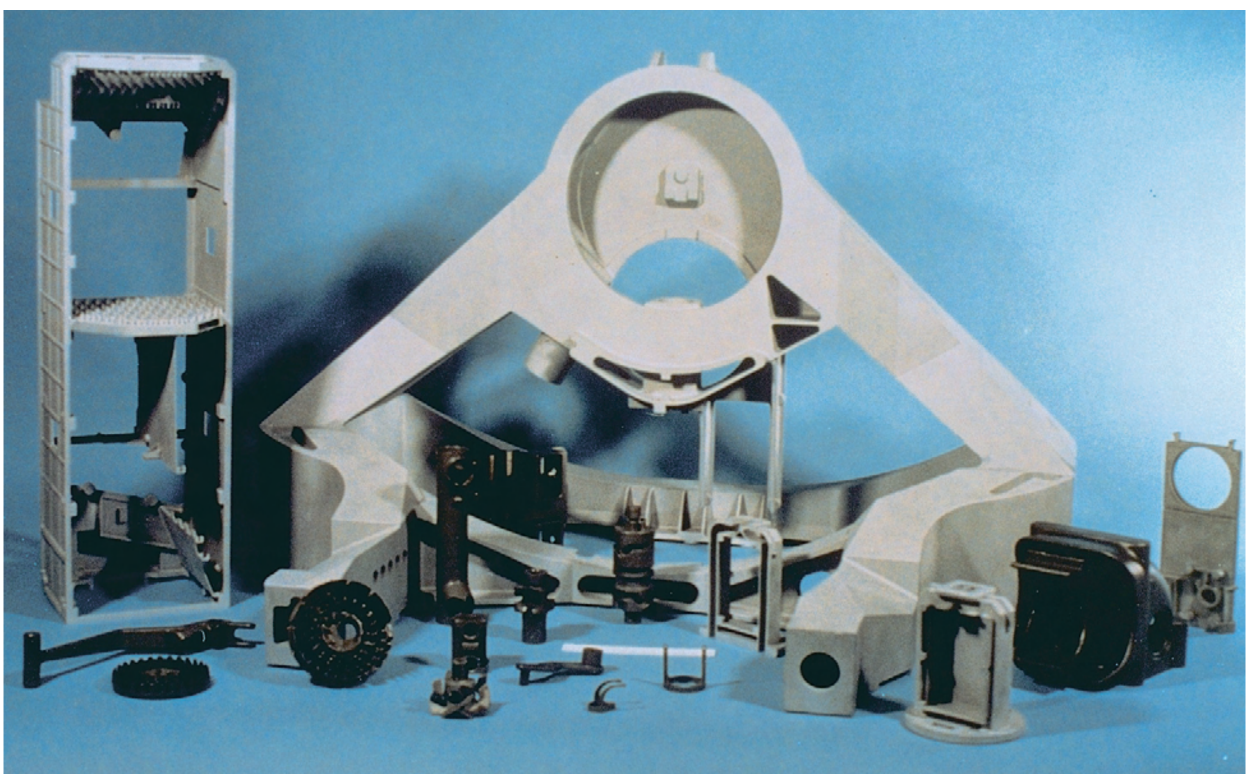

Recently, new uses have been found for lost wax casting. It is one technique used to produce precision parts, such as these—designed using computers—for aircraft and other machines.