BIG IDEA

1.0 All fluids demonstrate the property of viscosity, or the internal friction that causes a fluid to resist flowing.

Fluids can be found everywhere. We drink them, we breathe them, and we use them. But how much do you know about fluids? In this Big Idea, you will have an opportunity to investigate an important property of fluids called viscosity.

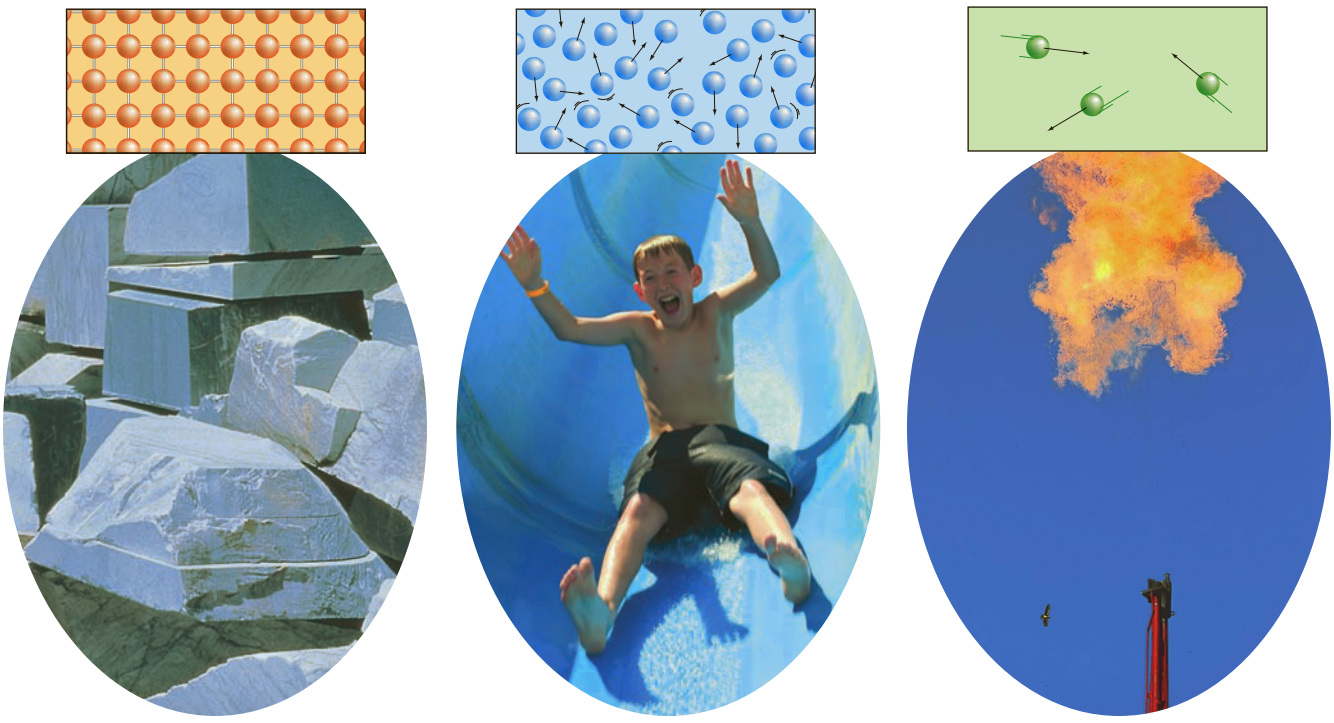
1.1 Investigating Viscosity

EXPLORE

The **Particle Theory of Matter** attempts to explain matter in a number of ways. It describes:

- a model of matter
- the different states of matter
- what happens when matter changes from one state to another

This model helps you understand and explain observations you will make when investigating matter.



The Particle Theory describes how particles behave in each of the three states of matter. When matter is a solid, the particles are close together and fixed in place. In a liquid, they are close together, but can slide around and over each other. In a gas, the particles are far apart and move around rapidly. A brief review of the Particle Theory is on the right.

Can the Particle Theory be used to describe fluids and how they behave? And what exactly are fluids? Use the Particle Theory and your observations from the Investigator: *Is it a fluid?* to improve your definition of a fluid.

Most people think of liquids when they hear the word "fluid." But gases are also fluids. In fact, we can think of a **fluid** as any matter that has no fixed shape but that takes the shape of its container. For example, the air in a bicycle tire takes the shape of the tire. The air in a beach ball takes the shape of the ball. In the same way, water in a bottle takes the shape of the bottle, but in a bowl, it takes the shape of the bowl. In this unit, you will investigate the properties of fluids. In many of these activities, you will use the Particle Theory to help explain your observations.

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Particle Theory Points

- All matter is made of tiny particles.
- Different substances are made of different particles.
- The particles of matter are always moving and vibrating.
- Particles move differently in solids, liquids, and gases.
- Adding heat makes particles move more and vibrate faster. As a result, the state of matter may change.

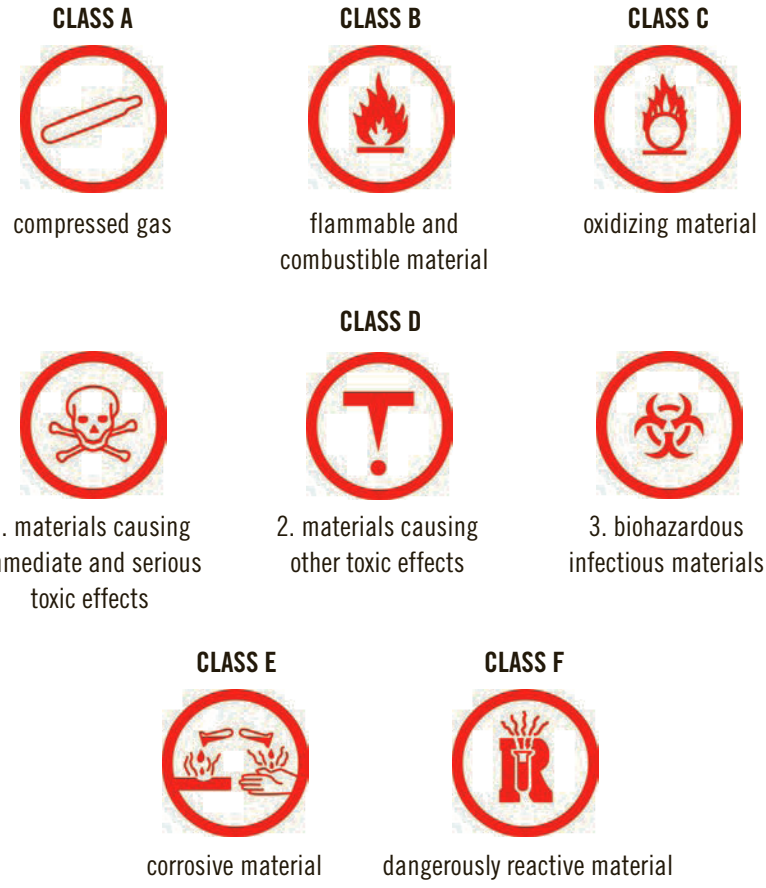
DEVELOP

Working Safely with Fluids

Before proceeding with the investigation of viscosity you need to think about safety. There are many fluids that are safe to handle — we eat them, put them on our skin, and swim in them. There are, however, some fluids that are unsafe. There are two different labelling systems used in Canada to help us know which fluids are safe and which fluids need to be handled cautiously. At home, you may have seen Hazardous Household Product Symbols (HHPS) on cleaning or automobile fluids found in your garage. These symbols tell you the level and type of danger.

Hazardous Household Product Symbols alert you to the level and type of danger.
The triangles indicate "caution" and the octagons indicate danger.
Remember, the more corners the symbol has, the greater the danger.

In all workplaces in Canada, including schools, you will see a second type of safety symbols. They are the Workplace Hazardous Materials Information System (WHMIS) safety symbols. You will see these symbols in your classroom, and it is important to know what they mean. Understanding WHMIS symbols can help you handle dangerous materials safely.



Knowing WHMIS Classes and Hazard Symbols will help you stay safe when handling materials in the classroom.

It is important to stay safe in the science lab. Check the label of all materials to determine whether they are potentially dangerous. Refer to Toolkit 1 for more safety information before you begin labwork for this unit.

Viscosity

One property of fluids is how they move or flow. Think about the fluids you have used in the last couple of days. How would using them be different if they did not flow the way they usually do? For example, what if soda pop was like a thick syrup or ketchup was like water? In both these situations, the properties of the fluids are dramatically different.

With your partner, look at the five fluids that you listed in the Focus Your Thoughts at the beginning of this unit. Describe what they would be like if they were thicker or if they were thinner. Here is an example:

Fluid	Thicker	Thinner
Shampoo	• hard to get out of bottle	• would take a lot to wash hair

How fluids flow is determined by a property called viscosity. **Viscosity** is a liquid's internal resistance or friction that keeps it from flowing. Recall from the Particle Theory that the particles in a liquid slide around and roll over each other. In a gas, the particles move around more easily because they are far apart. In a fluid, the greater the friction or rubbing between the particles, the higher the viscosity. Fluids with a high viscosity do not flow as easily as fluids with a low viscosity.

Juice has a low viscosity.

Ketchup has a high viscosity.

There are several ways to determine the viscosity of fluids. Two common ways you will investigate are the bubble test and the ramp method.

- In the **bubble test**, you time how long it takes an air bubble to rise through a tube of fluid.
- In the **ramp method**, you time how long it takes a fluid to flow down a ramp.

The longer it takes for the bubble to travel through a fluid, or for a fluid to flow down a ramp, the higher its viscosity.

When you are performing a scientific investigation, such as the bubble test or ramp method, it is important to control the **variables**, or things that can be changed. You will be performing a **fair test** when you ensure that only one part of your experiment, or one variable, is being changed at a time. That way, you will know that the changes you observe are due to the one variable you are changing.

INVESTIGATOR

The Bubble Test

Before You Start

Look at the labels of the fluids you are working with. Are there safety concerns with any of them?

After observing the liquids in the containers, predict how the viscosity of the liquids tested will compare to each other. List them in order, from most viscous to least viscous.

The Question

How can you compare the viscosity of different liquids?

Materials & Equipment

- 5 clear plastic tubes (cut into different lengths from 5–30 cm)
- 10 stoppers or plugs (medicine dropper bulbs, binder clips, etc.)
- stopwatch
- funnel
- 5 liquids: water, liquid furniture or floor polish, shampoo, pancake or table syrup, vegetable oil

Procedure

1. Make a mark on each tube at 2 cm from the end.

Step 1: Mark each tube at 2 cm from the end.

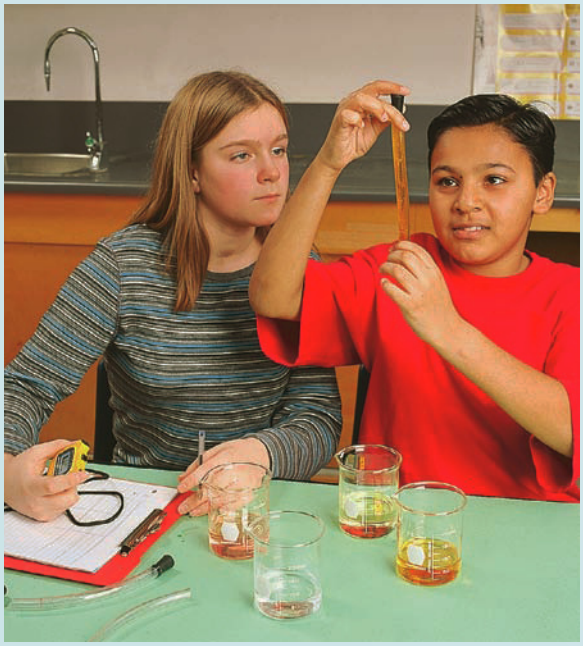
2. Draw a data table similar to the one shown below.

Time for Bubble Test				
Fluid	Trial 1	Trial 2	Trial 3	Average Time

3. Place a stopper in the unmarked end of a tube. Use the funnel to fill the tube up to the mark with one of the liquids.

4. Seal the marked end of the tube with a second stopper.

5. Hold the tube vertical, then turn it upside down. At the moment that you turn the tube upside down, start your stopwatch. Make sure to hold the tube vertical once again.



Step 5: Turn the tube upside down.

6. In your table, record the time it takes for the bubble to reach the top of the tube.

7. Repeat steps 5 and 6 two more times with the same tube and record the times in a table of results.

8. Repeat steps 3 through 7 for each liquid.

Analyzing and Interpreting

9. Look at the three measurements you took for the first liquid. Is one of these measurements very different from the other two? If so, circle this one and do not include it when you calculate the average time. Do the same for the readings for all the other liquids. There could be an error in these circled measurements. You will look at them later in question 13, part f).

10. Calculate the average time that each bubble took to move up its tube of fluid.

11. Based on your results, list the fluids in order from most viscous to least viscous.

12. Compare your results to your prediction.

Forming Conclusions

13. Write a summary for your investigation using the following questions as a guide.
    a) What question were you trying to answer?
    b) What did you do?
    c) What variables did you try to control?
    d) What were your results?
    e) How did your results compare to your prediction?
    f) What sources of error or problems did you encounter? (If you had an error in measurement, describe why and how you think it happened.)
    g) What safety precautions were needed with these fluids?

Viscosity Is Important

Think back again to the five fluids you identified in the Focus Your Thoughts section at the beginning of this unit. How might you change the viscosity of these fluids? Why would you want to? For example, when you are cooking, you can change the viscosity of gravy. If the gravy's viscosity is too low, you need to add more flour. If its viscosity is too high, you need to add water.

The shape of the particles in a fluid helps to determine its viscosity.

So, what causes some fluids to have higher viscosity than others? Think of how glue feels on your fingertips. It feels sticky because the glue particles are attracted to your skin. Similarly, certain types of particles attract each other more than others. It is hard for these particles to flow or move easily by each other. Even though all fluids flow, the greater the attraction between particles, the higher the viscosity. The attraction between fluid particles is related to their size and shape. Small particles can move past each other more easily, resulting in a lower viscosity. As well, some particle shapes flow past each other more easily.

Imagine a container full of marbles or buttons and a container full of yarn strands. If you dump both jars out, the marbles or buttons easily move around each other and flow through a space, while the yarn strands get caught on each other. This result is similar to the effect of particle shape on viscosity.

COMMUNICATE

1 Write a short paragraph to describe viscosity. Include at least two examples of fluids and use the words *flow*, *fluid*, *particles*, and *viscosity* in your description.

2 Which of the following materials is the most viscous? Which is the least viscous? How could you determine this?
a) syrup
b) house paint
c) water

3 Describe two substances that are useful because of their viscosity. What criteria would you use to determine if a brand name of that substance is high quality or not?

4 How can you ensure a fair test if you are trying to compare the viscosities of two different substances?