

- Although many gases are invisible, their properties can be measured, such as the volume, temperature, density, and pressure exerted by a gas. The properties of gases can also be observed through chemical reactions. By observing the products of a chemical reaction, you can determine the nature of the reactant gases.
- A hot-air balloon rises because, as the air is heated inside, the gas particles move more quickly and the volume of the gas increases. As the volume increases, the density of the gas becomes less than the air surrounding the balloon. A gas of lower density will rise through a more dense gas until the densities of the two gases are equal. Therefore, the balloon will continue to rise until the density of the air in the balloon equals the density of the atmospheric air.
- The quality of air in the atmosphere is affected by the amounts of pollutants present. These pollutants include nitrogen oxides, sulfur dioxide, carbon dioxide, volatile organic compounds, ground-level ozone, heavy metals, and other toxins.

## 4.1 WATER: ESSENTIAL FOR LIFE

### TRY THIS ACTIVITY: HOW MUCH WATER IS ESSENTIAL?

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- Student answers may vary. **Tables 2 and 3** present an example of water used in a home of two people.

**Table 2** Water-Use Journal for Family Member 1

Water use	Number of times in one day	Total for three days	Average amount of water used	Actual amount of water used (L)
<b>Bathroom</b>				
flushing toilet	4	12	× 18 L	216
showering (10 min)	1	3	× 100 L	300
bathing in tub	0	0	× 60 L	0
brushing teeth*	0	0	× 10 L	0
shaving	1	3	× 20 L	60
washing hands	5	15	× 8 L	120
<b>Kitchen</b>				
cooking	2	6	× 20 L	120
washing dishes by hand	1	3	× 35 L	105
using dishwasher	0	0	× 40 L	0
<b>Laundry</b>				
using washing machine	1	3	× 225 L	675
<b>Outside</b>				
washing car*	0	0	× 400 L	0
watering lawn	0	0	× 35 L/min	0
Total water used 1596 L				

\* while water is running

**Table 2** Water-Use Journal for Family Member 2

Water use	Number of times in one day	Total for three days	Average amount of water used	Actual amount of water used (L)
<b>Bathroom</b>				
flushing toilet	3	9	× 18 L	162
showering (10 min)	1	3	× 100 L	300
bathing in tub	0	0	× 60 L	0
brushing teeth*	0	0	× 10 L	0
shaving	0	0	× 20 L	0
washing hands	6	18	× 8 L	144
<b>Kitchen</b>				
cooking	1	3	× 20 L	60
washing dishes by hand	1	3	× 35 L	105
using dishwasher	0	0	× 40 L	0
<b>Laundry</b>				
using washing machine	0	0	× 225 L	0
<b>Outside</b>				
washing car*	0	0	× 400 L	0
watering lawn	0	0	× 35 L/min	0
Total water used 771 L				

\* while water is running

2. (b) The quantity of water used by family member 1 for each activity over three days was 1596 L. The quantity of water used by family member 2 over three days was 771 L. The total volume of water used over the three-day period was 2367 L.
- (c) The average volume of water used by family member 1 in one day is. The average volume of water used by family member 2 in one day is  $\frac{1596 \text{ L}}{3 \text{ d}} = 532 \text{ L}$   $\frac{771 \text{ L}}{3 \text{ d}} = 257 \text{ L/d}$ .
- This home uses about 789 L of water in one day  $\left( \frac{1596 \text{ L} + 771 \text{ L}}{3 \text{ d}} \right)$ .
- (d) Student answers may vary. Possible ways of conserving water could include reducing the number of times dishes are washed, reducing the number of times that clothes are washed, and turning off the water when brushing teeth and washing the car.

## SECTION 4.1 QUESTIONS

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### Understanding Concepts

- Water is stored as surface water on Earth's surface in oceans, lakes, rivers, and streams. Water is also stored as ground water in porous rock formations, or aquifers.
- The total supply of water on Earth remains the same because of the water cycle. Energy from the Sun causes water to evaporate and rise. As the water vapour rises, it cools and condenses into mist, fog, and clouds. When the water

vapour condenses into a liquid, it returns to Earth as precipitation (rain, snow, sleet, and hail). All water is conserved as this cycle repeats itself.

3. (a) Water is a polar molecule that consists of an oxygen atom covalently bonded to two hydrogen atoms. The large difference between the electronegativity of each hydrogen atom and the electronegativity of the oxygen atom produces a highly polar bond. The bonds between the hydrogen and oxygen atoms in a water molecule are polar covalent bonds.  
(b) A water molecule is V-shaped, or bent, because the oxygen atom in a water molecule has two single polar covalent bonds and two lone pairs of electrons.
4. (a) Water has a high boiling point (100°C) because large amounts of energy are required to break the hydrogen bonds between water molecules in the liquid state. Hydrogen sulfide,  $\text{H}_2\text{S}$ , has a similar structure to water, but it has a much lower boiling point because hydrogen sulfide molecules do not form hydrogen bonds with each other. Since there are only weak intermolecular forces between the molecules, hydrogen sulfide molecules are found in the gaseous state at a much lower temperature than water molecules. Refer to **Figure 5** in the Student Text for a depiction of hydrogen bonds between water molecules.  
(b) The strong hydrogen bonds between water molecules allow water to absorb a large quantity of kinetic energy before undergoing a change of state. Thus, water has a high heat capacity relative to most other substances.  
(c) Water has a very high heat capacity, which means that it can hold a lot of heat. Large bodies of water, such as oceans or the Great Lakes, can act as heat reservoirs, or sinks. The body of water absorbs a large amount of heat in the summer before the water temperature increases significantly. Prevailing winds that move across the cool water help to moderate warmer temperatures over adjacent land masses. When the temperature of the air decreases, the heat that is stored in the water moderates the colder air temperatures over adjacent land masses.  
(d) Unlike most other substances, as liquid water freezes, its density decreases and it expands to occupy a larger volume than it did as a liquid. Therefore, as water freezes in cracks and crevices in roadways during the winter, it expands and causes these cracks to widen. In the summer, temperatures are above freezing and liquid water does not undergo a change of state. Thus, there is no pressure of expanding ice in the crevices of roadways during the summer.
5. (a) A polar molecule is slightly positively charged at one end and slightly negatively charged at the other end. A water molecule is considered to be polar because there is an uneven distribution of electric charge between the oxygen atom and the hydrogen atoms. The oxygen atom has a slight negative charge and the two hydrogen atoms have a positive charge.  
(b) Since water molecules are polar, they are attracted to a wide variety of electrically charged particles, or ions, and other polar substances. Therefore, many substances can be dissolved in water.
6. (a) The crude oil spilling from the tanker is less dense than seawater and, thus, will float on the surface. Aquatic birds and animals will be most affected. Mostly likely, fish will not be seriously affected because they spend most of their lives under the ocean's surface.  
(b) Since the oil spilling from the tanker is less dense than seawater, it will float on the surface of the water where it will be subjected to waves, currents, and wind. Thus, the oil can disperse over hundreds of kilometres. Oil-spill cleanup operations are often very difficult because of the difficulty in containing the oil.  
(c) Although it may seem unusual for a substance to burn on the surface of water, the possibility of an oil fire is very high. Since oil floats on the surface of the water, such a fire cannot be easily extinguished.

### Making Connections

7. Oceans contain about 97% of Earth's water, although this water is not suitable for drinking because of its high salt content. Of the 2% of the Earth's water supply that is fresh water, less than 0.4% is directly available for use.
8. (a) Student answers may vary. Suggestions for reducing water consumption could include eliminating such water uses as laundry, washing dishes, and outside water uses (washing the car, watering the lawn).  
(b) By eliminating these activities, a supply of clean clothes and dishes would diminish if the water shortage continued for an extended period.