(c) Student answers may vary. The health effects of drinking softened water appear to be debated widely. Many people believe that drinking salt-softened water increases sodium levels in the body, which can lead to the development of heart disease. Generally, the amount of sodium added to the water is very low. Studies have shown, however, that drinking softened water can be harmful to people on a sodium restricted diet or to bottle-fed babies less than six months old.

There is also debate as to whether people who drink softened water experience mineral deficiencies. Generally, requirements for minerals are met by eating foods, not drinking water. Studies have shown that people who drink naturally soft water do not suffer from mineral deficiencies.

One study investigated the possibility that softened water increases the potential for leaching heavy metals from pipes and plumbing fixtures. High levels of heavy metals are associated with health problems. Increased levels of copper, lead, zinc, and cadmium have been found in soft water, particularly when it stands overnight in the plumbing system.

4.3 WHAT'S IN POLLUTED WATER?

CAREER CONNECTION: WATER TREATMENT PLANT OPERATOR

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(i) The most important aspect of a water treatment plant operator's job is collecting water samples for analyses and recording the test results. A water treatment plant operator must be organized and able to carefully record the details of test results and actions performed to provide an accurate record for tracking purposes. Without such organization, a water system can quickly become contaminated.

(ii) Programs are offered at various community colleges. For example, Fanshawe College offers Cooperative Education in Environmental Science. Duties involved in cooperative postings include performing chemical, physical, and microbiological analyses of water from water treatment plants, maintaining records of analytical results, and ensuring that lab equipment functions properly. Once students have completed the course, they are eligible to write the Water Quality Analyst (WQA) examination. Upon successful completion, students receive a licence and may perform analytical tests on drinking water within water treatment facilities. Students are also eligible to write the Operator-In-Training (OIT) certification examination. Upon successful completion, students may pursue a career as an operator of a water and wastewater treatment facility.

Courses for Environmental Technician (ETN) are also offered at Sir Sanford Fleming College. Students receive hands-on training with access to environmental training facilities and a biological water treatment system. Fleming also offers the use of the Alternative Wastewater Treatment Centre, a research facility for designing and testing small-scale wetland treatment systems.

(iii) The average starting salary for an Environmental Technician is $31,400.

(iv) The demand for Environmental Technicians in water treatment operations is high. Fanshawe College reports that 88% of recent graduates from the Environmental Technician program are employed in related positions. Fleming reports that 92% of graduates work in the environmental field.

SECTION 4.3 QUESTIONS

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Understanding Concepts

1. (a) The three types of contaminants that contribute to water pollution are physical contaminants, which do not dissolve in water, biological contaminants, which include viruses and bacteria, and chemical contaminants.

(b) Student answers may vary. **Table 1** lists some possible answers.

Table 1 Water Pollutants

Physical contaminant	Biological contaminant	Chemical contaminant
• silt • clay • debris • garbage	• *E. coli* • coliform bacteria • *Cryptosporidium* • *Giardia* • *Campylobacter*	• metals • fertilizers • petroleum products • pesticides • toxins

2. Student answers may vary. Answers could discuss how during heavy rainfall, water containing surface contaminants can run directly into surface water or underground wells. For example, this is how *E. coli* bacteria contaminated the water system in Walkerton, Ontario. Another way in which pollutants can enter surface water and ground water involves landfill sites. Chemical contaminants from wastes buried at landfill sites may leak, run off, or leach into surface or ground water.
3. 5.4 mg nitrate ion in 10 mL water = 540 mg/L
   According to **Table 2** in the Student Text, the MAC level for nitrate is 10.0 mg/L. Thus, 540 ppm nitrate exceeds the acceptable level. The water is therefore unsafe to drink.
4. Federal–provincial water quality guidelines list the maximum acceptable concentrations (MAC) of chemicals that can be in drinking water after treatment. It is important that these levels of contaminants in drinking water not be exceeded to ensure that all people of a community remain healthy.

Making Connections

5. (a) Amount of water in one year = 1.5 L × 365 d/a = 547.5 L
   amount of lead in 547.5 L = 0.01 mg/L × 547.5 L = 5.48 mg
   Thus, an average person would consume 5.5 mg of lead in one year.
   (b) Students should indicate that they would not willingly drink this water. Although the water contains levels of lead that do not exceed the maximum acceptable concentration, over one year, the amount of lead consumed is quite significant. Since lead accumulates in body tissues, a person would obtain fairly high levels of lead after a few years of drinking this water.
6. (a) Student answers may vary depending on the brand of bottled water chosen. A few brands are described below.
   - Evian water is from precipitation that falls on the French Alps. The water filters through rocks as it travels down the mountains to emerge in the town of Evian-Les-Bains.
   - Dasani water comes from local water that has been filtered using reverse osmosis. Minerals are added to the water to enhance the taste.
   - Volvic water is water that filters through Auvergne rocks. As the water travels through the rocks, it dissolves minerals that give the water a unique taste.
   - Aquafina is water that has been treated through reverse osmosis and carbon filtration.
   - Esker Natural Spring Water is water that has been extracted from an esker, a rare geological formation located in the Abitibi region of Quebec.

   (b) The Canadian Food Inspection Agency regulates manufacturers and importers of bottled water to ensure that products meet Canadian health and safety standards. Quality standards are similar for both bottled and municipal waters. Bottled water that meets required health and safety standards is considered to be safe. No waterborne disease outbreaks have been associated with drinking bottled water in Canada.
   (c) Student answers may vary. The student may feel that quality standards for bottled water are adequate considering they are the same as the standards for municipal water. However, the student may also feel that bottled water should have additional requirements above and beyond municipal standards since bottled water has a higher cost. For example, a student may assume that bottled water costs more and, thus, is of higher quality than municipal water.
7. (a) Student answers will vary depending on locality. The following example is for the water supply for London, Ontario.

   The City of London, Ontario, receives its water from the Elgin Area Primary Water Supply System, which is 2 km east of Port Stanley. This system can treat up to 90 million L/day. On average, the facility treats 53 million L/day.

   The water intake for the water treatment facility is located 1.5 km offshore in Lake Erie, where the water is about 10 m deep. By 2010, it is expected that 181 million L of water per day will flow through the intake crib.

   The water treatment system uses chemically assisted flocculation and sedimentation systems, dual-media filtration, and chlorine as the primary disinfectant. The treatment system and the water quality are continuously monitored. Four discharge pumps pump the water from the treatment plant through a 15-km pipeline to the St. Thomas Terminal Reservoir. There the water is re-pumped to London and surrounding areas. During high demand periods, typically in the summer months, an intermediate reservoir and booster pumping station, located near West McGillivray, is used to boost the water from the Lake Huron Water Supply System to the City of London.

   (b) Possible sources of water contaminants include mining waste, industrial effluent, spilled fuel, landfill sites, old plumbing, agricultural runoff, dry cleaners, and excess water chlorination. Biological contaminants, such as viruses and bacteria, may come from sewage treatment plants, septic systems, agricultural livestock operations, and wildlife.

(c) To ensure the safety of drinking water, levels of heavy metals, biological contaminants, and chemical contamination are measured continuously using online analyzers and computerized systems. Levels of contaminants must be within the limits identified in the Ontario Drinking Water Standards (MAC levels). These standards ensure that drinking water does not contain disease-causing organisms or unsafe levels of toxic chemicals. Drinking water should also be clear and colourless (aesthetic objectives).

(d) If tests indicate that the MAC of a substance has been exceeded, the local medical officer of health and the Ministry of the Environment are notified. Notices are submitted to the public via the local media and the Internet. The water is retested and monitored until the problem is corrected. "Boil water" advisories may be issued if the MAC of a biological contaminant has been exceeded.

8. Student answers may vary. Information about some physical and chemical portable water treatment methods is summarized in **Table 2**.

Table 2 Comparisons of Portable Water Treatments

Method	Use	Effective against pathogens		
		Protozoa	Bacteria	Viruses
boil water (3–10 min)	• requires heat source	yes	yes	yes
add chlorine	• easy to use • forms by-products (THMs)	most except *Cryptosporidium*	yes	yes
add iodine	• best when used with a filter • cold water requires higher levels and more time • some people should not drink iodinated water	some protozoa highly resistant to iodine	yes	yes
add chlorine dioxide	• easy to use • less temperature-sensitive than iodine • no by-products formed • expensive over long periods	yes	yes	yes
filter (0.5 microns or smaller)	• remove larger pathogens	yes	larger bacteria	no
treat water with iodine and then filter	• filter removes iodine • takes time for iodine to work	yes	yes	yes

4.4 INVESTIGATION: TESTING FOR IONS IN WATER

(Pages 285–287)

Prediction

(a) Student answers may vary. Depending on the local water supply, a water sample may contain many ions including iron, Fe^{3+}, calcium, Ca^{2+}, or sulfate, SO_4^{2-} ions.