Making Connections

11. Points in favour: patients would have to swallow less of the medicine; the medicines would be more compact and could be sold in smaller bottles, which might result in a lower cost (although the saving is likely to be minimal).

    Points against: selling medicines in highly concentrated solutions would almost certainly increase the frequency of patients accidentally taking the wrong dose (an extra 5 mL would contain considerably more of the active ingredient in a concentrated solution than in a dilute solution); more precise equipment would be required for measuring the appropriate quantity for the prescription and the dose.
12. A common system of communication is crucial for clarity, so there is no confusion about concentrations of blood test results or drug dosages. There are currently several systems for communicating the concentration of medicines, although all are metric. That all systems are metric is important for international communication and for labelling of bottles of medicine.
    - Percent composition is very common for medicines dispensed in solution (e.g., salicylic acid in acne preparations and D5W intravenous (5% dextrose in water)).
    - Percent concentration may also be used for blood-test results such as percent of alcohol (e.g., a maximum limit of 0.080% for drinking and driving).
    - Molar concentrations are used for blood sugar analysis where units of millimoles per litre (e.g., 5.1 mmol/L) are employed.
    - Parts per million and/or milligrams per kilogram of body mass are used when very small concentrations are involved (e.g., testing for toxins or drug-enhanced sports performances). The effective concentration of medicines are determined by extensive research with animals and humans. Once the concentration is determined through research, the effective mass of medicine that needs to be ingested every so-many hours is calculated. Taking one capsule of a medicine every 8 h or at every meal maintains an effective concentration of the chemical in the body systems. Time-release medication and patches are newer technologies that release the medication slowly in order to keep the concentration of the medication fairly constant over time. Sometimes, such as in chemotherapy, the concentration of chemicals is kept near the toxic level for the patient. Very careful monitoring of the concentrations of the chemicals in the blood system is required.

    Miscommunication of concentration levels can, of course, result in death. Conventions of communication are not just convenient and money saving; they also save lives.

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6.4 DRINKING WATER

PRACTICE

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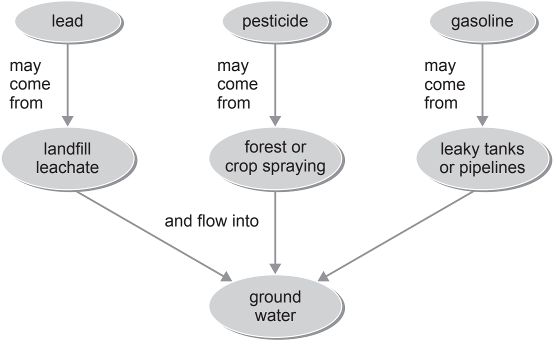
Understanding Concepts

1. Contaminants are biological (e.g., viruses, bacteria, protozoa), chemical (e.g., mercury, lead, PCBs) and physical (e.g., sand, mud, suspended particles of organic matter).
2. Some ways contaminants enter water are by leaching from landfills; from inadequate septic/sewage systems; from overuse of fertilizers, pesticides and herbicides; from livestock wastes; and from road salt runoff.
3. Leaking sewer pipes are environmental hazards because untreated sewage contains nitrates and phosphates (which can act as fertilizers in the environment) and bacteria (which can cause a variety of infections resulting in illness). Raw sewage also has a very unpleasant odour.
4. Water leaching from a landfill site may seep through the surrounding earth and rock, and into wells or streams, thus ending up in a drinking water supply. Such leachate could contain heavy metal ions (e.g., mercury, lead, and cadmium); bacteria; acids; and organic compounds (e.g., benzene and tetrachloromethylene). If not removed, these pollutants could have a negative influence on health: heavy metal ions interfere with brain and nerve development; bacteria can cause infections; acids can damage pipes; and organic compounds may be poisonous or carcinogenic.

5.



6. $c_{\text{tetrachloroethylene}} = 0.03 \text{ ppm} = 0.03 \text{ mg/L}$
$v_{\text{water}} = 250 \text{ L}$

$$m_{\text{tetrachloroethylene}} = 250 \cancel{\text{L}} \times \frac{0.03 \text{ mg}}{1 \cancel{\text{L}}}$$
$$m_{\text{tetrachloroethylene}} = 8 \text{ mg}$$

The mass of tetrachloroethylene in the bath water is 8 mg.

7. $c_{\text{cadmium}} = 0.005 \text{ ppm} = 0.005 \text{ mg/L}$
$c_{\text{lead}} = 0.010 \text{ ppm} = 0.010 \text{ mg/L}$
$c_{\text{mercury}} = 0.001 \text{ ppm} = 0.001 \text{ mg/L}$

$$v_{\text{water}} = \frac{1.5 \text{ L}}{1 \cancel{\text{d}}} \times \frac{365.25 \cancel{\text{d}}}{1 \text{ a}}$$
$$= 5.5 \times 10^2 \text{ L/a}$$
$$m_{\text{cadmium}} = \frac{5.5 \times 10^2 \cancel{\text{L}}}{1 \text{ a}} \times \frac{0.005 \text{ mg}}{1 \cancel{\text{L}}}$$
$$m_{\text{cadmium}} = 3 \text{ mg/a}$$

The mass of cadmium consumed per year would be 3 mg.

$$m_{\text{lead}} = \frac{5.5 \times 10^2 \cancel{\text{L}}}{1 \text{ a}} \times \frac{0.010 \text{ mg}}{1 \cancel{\text{L}}}$$
$$m_{\text{lead}} = 5.5 \text{ mg/a}$$

The mass of lead consumed per year would be 5.5 mg/a.

$$m_{\text{mercury}} = \frac{5.5 \times 10^2 \cancel{\text{L}}}{1 \text{ a}} \times \frac{0.001 \text{ mg}}{1 \cancel{\text{L}}}$$
$$m_{\text{mercury}} = 0.5 \text{ mg/a}$$

The mass of mercury consumed per year would be 0.5 mg.

8. $v_{\text{water}} = 10.00 \text{ mL} = 0.01000 \text{ L}$
$m_{NO_3^-} = 5.4 \text{ mg}$

$$c_{NO_3^-} = \frac{5.4 \text{ mg}}{0.01000 \text{ L}}$$
$$c_{NO_3^-} = 0.54 \text{ g/L}$$

This concentration of nitrate ion, 0.54 g/L, is much higher than the MAC level, about 540/45, or 12 times the acceptable maximum.

Making Connections

9. Student reports will vary widely. Suitable starting points for research include the Ontario Groundwater Management program, the Ontario Ministry of Agriculture, Food and Rural Affairs, and reports from the Walkerton Inquiry. Locally relevant issues should also be investigated.

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10. Student reports will vary. The chosen source of contamination could be any of those listed in Table 1, page 293 of the text. A proposed solution could involve preventing the contamination at source, preventing the contaminant from reaching the well, relocating the well, or removing the contaminant from well water before it reaches our taps.

Try This Activity: Simulated Water Treatment

(Page 297)

(a) In glass 1, a control, adding a teaspoon (5 mL) of ammonia to the alum solution causes a white flocculent precipitate to form. The nature of the precipitate is observed. The precipitate gradually settles to the bottom of the glass.

In glass 2, the components are added in the order water, soil, alum, and ammonia, and the contents clear as the flocculent precipitate settles. The removal of the suspended silt is obvious. The soil/silt adheres to the precipitate. The process is much more complete and quicker than in glass 3.

In glass 3, a control with water and soil only, the soil gradually settles but leaves some of the silt in suspension for a longer period of time than in glass 2.

(b) The precipitate, being gelatinous, will quickly clog a filter paper, making separation by filtration impractical. Allowing the precipitate to fall to the bottom of the container is slower, but simple and effective.

PRACTICE

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Understanding Concepts

11. Disinfection — killing disease-causing organisms — is the most important step in water treatment.

12.

Usual (all areas)	**Optional (some areas)**
collection	aeration
coagulation/sedimentation	softening
filtration	fluoridation
disinfection	
postchlorination	
ammoniation	

Making Connections

13. Physical treatments might include a variety of filters, such as ceramic, ultrafine, and carbon, plus reverse osmosis. The pore sizes in the most common filters sold today are 0.1-4 μm. Cysts and bacteria are removed by the filter, but viruses are too small. Boiling the water is effective for disinfecting the water completely.

Chemical treatments might include the use of iodine crystals, iodine-complex tablets, chlorine bleach, calcium hypochlorite crystals, and halazone tablets. The iodine, for example, is added as a measured volume of a saturated solution. The dilution procedure adds 4 mg of iodine to 1 L of water to produce a 4 ppm solution that is treated for 20 – 30 min before drinking.

Note that information on purifying water while hiking is also readily available at outdoor activity stores.

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14. In favour of bottled water: we can be fairly certain that it is free of microorganisms and toxic chemicals; distilled or reverse osmosis-treated water is much more pure; bottled water is convenient, if tap water is contaminated.

Against bottled water: most bottled water is not significantly different from that available through most municipal systems; bottled water may, in fact, be less safe than local municipally treated water; it is more expensive than tap water, and distilled or reverse osmosis-treated water is particularly expensive; it is less convenient (e.g. it has to be moved from storage to display areas, and it is heavy).

The note to the school cafeteria should outline a position and give reasons. It could also request some action on the part of the cafeteria staff, such as making free tap water available to all students.

15. Water testing, at anything other than a very basic level, is really a branch of analytical chemistry. A person trained as a laboratory technologist can analyze water for chemicals that may be present. However, the analysis also needs to include screening for possible biological components. The water must be tested for bacteria (e.g., E-coli), intestinal parasites (e.g., Giardia cysts and cryptosporidium), and viruses. Special equipment and training are required for the bioanalysis. The water-treatment plant operators must also be trained in the interpretation of analytical reports and in how to respond to these reports (how to adjust the process to remedy any problems).

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Explore an Issue

Take a Stand: Safe to Drink?

(Page 299)

(a) Aspects chosen may include: the choice of ground or surface water as a source; the location of wells or intake pipes; the age and condition of the pipes; the treatment the water receives; water metering; or the privatization of water delivery. The letter should clearly state the current situation (found through research) and make reasonable suggestions for improvements.

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SECTION 6.4 QUESTIONS

(Page 300)

Understanding Concepts

1. A typical list might be taken from Section 6.4; Tables 1, 2, and 3:

Pollutant	Classification
acid	chemical
bacteria	biological
cysts	biological
viruses	biological
lead	chemical
mercury	chemical
cadmium	chemical
mineral solids	physical
nitrates	chemical
phosphates	chemical
organic compounds	chemical
benzene	chemical
gasoline	chemical
pesticides	chemical
salt	chemical

2. The first action should be to notify the community to stop using the water. Next, the water supply system must be disinfected and flushed.
3. Exceding the MAC for chemicals in drinking water is a potential health hazard. For example, high lead levels can cause brain damage; organic compounds may be carcinogenic; salt makes water taste bad and may contribute to circulatory problems.
4. Contaminants may be any of those listed in Tables 2 or 3. If benzene is chosen, the presentation should include its source (e.g., leaked gasoline, industrial effluent, or landfill leachate); its MAC (0.005 ppm); and its effects (it is a suspected carcinogen and, because it floats on water, it interferes with water's ability to exchange gases with the air).

   Research information is plentiful on water contaminants. Students might be encouraged to report on a contaminant that poses a problem locally.
5. A lead concentration of 0.01 g/L is 1000 times higher than the MAC level of 0.010 mg/L (0.000010 g/L).

Making Connections

6. Water treatment is designed to remove physical, biological, and chemical contaminants. Physical contaminants are removed through coagulation, flocculation, sedimentation, and filtration; biological contaminants are removed through disinfection and postchlorination; chemical contaminants are removed through aeration and softening.

   Water treatment on a large scale is usually a continuous process (rather than a batch process) in order to provide a continuous flow of treated water into the water system. Continuous-flow designs are much more difficult to create and monitor because they must be timed correctly. The size of the container, the mixing of the fluids, and the time that a sample of water remains in the container must all be pre-engineered in order for the process to be effective. In a batch process, there are fewer variables to control and manipulate — the water is relatively static (still) while being treated.
7. In support of the statement: Almost any contamination problem eventually becomes a human (personal) problem because of the interconnectedness of the entire ecosystem, which, of course, includes us. Most ground water contamination is caused by people, so it is our responsibility to clean it up.
   In opposition to the statement: Contamination is a problem regardless of whether it affects people and should be avoided if at all possible. Humans are not the only organisms damaged by contamination.
   Presentations should include suppporting information and reasoned arguments.
8. Precise equipment is required for water testing because "safe" levels of toxic and noxious materials are so low that they are hard to measure with imprecise equipment.

6.5 SOLUTION PREPARATION

PRACTICE

(Page 302)

Understanding Concepts

1. In solid form, ammonium oxalate is a monohydrate, so the calculation of molar mass must take this into account.

$$C_{(NH_4)_2C_2O_4} = 0.250 \text{ mol/L}$$
$$v_{(NH_4)_2C_2O_4} = 100.0 \text{ mL} = 0.1000 \text{ L}$$
$$M_{(NH_4)_2C_2O_4\cdot H_2O} = 142.14 \text{ g/mol}$$
$$n_{(NH_4)_2C_2O_4} = 0.1000 \cancel{\text{L}} \times \frac{0.250 \text{ mol}}{1 \cancel{\text{L}}}$$
$$= 0.0250 \text{ mol}$$
$$m_{(NH_4)_2C_2O_4\cdot H_2O} = 0.0250 \cancel{\text{mol}} \times \frac{142.14 \text{ g}}{1 \cancel{\text{mol}}}$$
$$m_{(NH_4)_2C_2O_4\cdot H_2O} = 3.55 \text{ g}$$

or

$$m_{(NH_4)_2C_2O_4\cdot H_2O} = 0.1000 \cancel{\text{L}} \times \frac{0.250 \cancel{\text{mol}}}{1 \cancel{\text{L}}} \times \frac{142.14 \text{ g}}{1 \cancel{\text{mol}}}$$
$$m_{(NH_4)_2C_2O_4\cdot H_2O} = 3.55 \text{ g}$$

The mass of ammonium oxalate monohydrate required is 3.55 g.

2.
$$C_{NaOH} = 10.0 \text{ mol/L}$$
$$v_{NaOH} = 500 \text{ mL} = 0.500 \text{ L}$$
$$M_{NaOH} = 40.00 \text{ g/mol}$$
$$n_{NaOH} = 0.500 \cancel{\text{L}} \times \frac{10.0 \text{ mol}}{1 \cancel{\text{L}}}$$
$$= 5.00 \text{ mol}$$
$$m_{NaOH} = 5.00 \cancel{\text{mol}} \times \frac{40.00 \text{ g}}{1 \cancel{\text{mol}}}$$
$$m_{NaOH} = 200 \text{ g}$$

or

$$m_{NaOH} = 0.500 \cancel{\text{L}} \times \frac{10.0 \cancel{\text{mol}}}{1 \cancel{\text{L}}} \times \frac{40.00 \text{ g}}{1 \cancel{\text{mol}}}$$