(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.

Part 1: Qualitative Analysis of a Water Sample

Observations

Table 1 Ions in Drinking Water

Testing solution	Appearance	Distilled water			Tap water			Reference solution		
potassium thiocyanate, $KSCN_{(aq)}$	clear, colourless solution	no change	no change	no change	no change	no change	no change	red	red	red
sodium oxalate, $Na_2C_2O_{4(aq)}$	clear, colourless solution	no ppt forms	no ppt forms	no ppt forms	white ppt forms	white ppt forms	white ppt forms	white ppt forms	white ppt forms	white ppt forms

Analysis

(b) Student answers will vary depending on the water source used in the investigation. If a red colour formed after addition of potassium thiocyanate, $KSCN_{(aq)}$, to the tap water, iron ions, Fe^{3+}, are present. If a white precipitate formed after addition of acetic acid, $HC_2H_3O_{2(aq)}$, and sodium oxalate, $Na_2C_2O_{4(aq)}$, to the tap water, then calcium ions, Ca^{2+}, are present.

(c) Three samples are tested for each ion to reduce the effect of experimental error on the final results. By observing consistent results in three samples, you may have more confidence in your conclusions.

(d) A control is used for comparison. The control should give a reliable, predicted result. In this investigation, the distilled water was the control and was an example of a negative test. When potassium thiocyanate, $KSCN_{(aq)}$, or acetic acid, $C_2H_3O_{2(aq)}$, and sodium oxalate, $Na_2C_2O_{4(aq)}$, were added to the distilled water, there is no reaction unless the distilled water became contaminated.

(e) $Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \rightarrow Fe(SCN)^{2+}_{(aq)}$

$Ca^{2+}_{(aq)} + C_2O^{2-}_{4(aq)} \rightarrow CaC_2O_{4(s)}$

Evaluation

(f) Student answers will vary depending on the results of the investigation and the accuracy of the prediction.

(g) Student answers will vary. Improvements could include measuring the sample and test solutions more precisely.

(h) If a clean microdropper had not been used for each solution, the solutions would have become contaminated. For example, if the same microdropper had been used to measure iron(III) nitrate solution, $Fe(NO_3)_{3(aq)}$, and tap water, the tap water would be contaminated with iron(III) ions, Fe^{3+}. Likewise, use of the same microdropper with either tap water or iron(III) nitrate solution and distilled water would result in contamination of the distilled water.

Contamination of any of the solutions could very likely introduce error into the final results of the experiment. If contamination with iron(III) ions had occurred, it is possible that a false positive result (red colour) would be observed in either the tap or distilled water when tested with potassium thiocyanate, $KSCN_{(aq)}$.

Synthesis

(i) A negative test result (no colour or precipitate) does not necessarily indicate the absence of an ion in solution. The ion may be present in such small amounts that it does not produce enough colour or solid precipitate to be easily seen.

Part 2: Quantitative Analysis of a Water Sample

Observations

Table 2 Observations Collected in Part 2

mass of filter paper	0.631 g
mass of filter paper + precipitate	0.653 g
mass of precipitate	0.022 g or 22 mg

Analysis

(j) The appropriate balanced chemical equation is:
$SO_{4(aq)}^{2-} + Ba_{(aq)}^{2+} + \rightarrow BaSO_{4(s)}$
Results will vary depending on values obtained in the experiment. Using the data in **Table 2**,

$$[SO_{4(aq)}^{2-}] = \frac{22\ mg}{0.040\ L} = 550\ mg/L$$

The concentration of sulfate ions in the water sample is 550 mg/L.

(k) Answers may vary depending on experimental results. Using the data in (j), the concentration of sulfate ions in the local water supply is 550 ppm.

Evaluation

(l) Potential sources of error include recording an inaccurate mass for the filter paper and precipitate since most school laboratory scales are not precise for very small masses. Some precipitate could have been lost from not rinsing the beaker completely, while transferring the filter paper from the funnel to the 150-mL beaker, or while transferring the dried filter paper from the beaker to the scale. Other sources of error include measurement errors and insufficient drying.

(m) Suggestions for reducing the sources of error include placing the funnel and filter paper inside a beaker for drying instead of removing the wet filter paper from the funnel. Placing the funnel and filter paper inside a beaker for drying would prevent any loss of precipitate when transferring the wet filter paper from the funnel to the beaker. Taking care to make accurate measurements and using an accurate scale to measure the mass could also reduce experimental errors.

Synthesis

(n) Student answers may vary depending on experimental results. Using the sample data, the sulfate ion concentration was calculated to be 550 ppm. **Table 2** in Section 4.3 gives the aesthetic objective of sulfate as <500 ppm. Therefore, the sulfate concentration in the water sample exceeds the aesthetic objective.

4.5 TECH CONNECT: WATER DISINFECTION METHODS

TRY THIS ACTIVITY: A SIMPLE DISTILLATION

(Page 289)

(a) The liquid that collects on the underside of the watch glass is clear and colourless.

(b) Water vapour forms in the beaker because, as the water is being heated, it is evaporating, and changing from a liquid to a gaseous state.

(c) As the water vapour comes into contact with the cool watch glass, the water condenses, or changes from a gaseous to a liquid state.

(d) Student answers may vary. Students should explain that it appears that distillation has removed all traces of dissolved salt from the water since there is no visible residue remaining on the microscope slide after evaporation of the distilled water.

TECH CONNECT 4.5 QUESTIONS

(Page 289)

Understanding Concepts

1. Student answers may vary. Students may explain that most Canadians are concerned about biological contaminants in their water supply, rather than chemical and physical contamination, because of the Walkerton tragedy.