

## Assessment and Evaluation

| ThoughtLab/<br>ExpressLab/<br>Investigation                      | Curriculum<br>Expectations  | Assessment<br>Tools/Techniques  | Achievement<br>Chart Category     | Learning Skills                       |
|--|---|---|-----------------------------------|---------------------------------------|
| ThoughtLab:<br>Testing Hard Water<br>and Soft Water,<br>page 363 | <b>Specific Expectations</b><br><i>Understanding Basic Concepts</i><br>■ [SS 1.04] describe common combinations of aqueous solutions that result in the formation of precipitates | ■ Assessment Checklist 1: Designing an Experiment (see "Assessment and Evaluation" in the front matter of <i>Teacher's Resource</i> CD-ROM) | ■ Inquiry<br>■ Making Connections | ■ Works Independently<br>■ Initiative |

## Section Review Answers

### Student Textbook page 364

- Point source — steel industry, pulp and paper. Diffuse source — farm field runoff, acid rain. Indirect source — smokestacks, motor vehicles.
- Lowest acceptable are aldrin and dieldrin, highest acceptable is chloride. The rearrangement would be in the order: aldrin and dieldrin, mercury, benzene and cadmium, lead and selenium, toluene, arsenic, sulfide, uranium, aluminum, malathion, iron, fluoride, chloride.
- Lake Ontario is the source of water for the Hamilton, Niagara, and Toronto areas. Due to the limestone bedrock and many heavy industries the major ions present would be  $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Cl}^-$ ,  $\text{F}^-$ ,  $\text{Al}^{3+}$ ,  $\text{SO}_4^{2-}$ ,  $\text{CO}_3^{2-}$  and probably some more harmful heavy metal contaminants from the industries such as  $\text{Pb}^{2+}$  and  $\text{Cd}^{2+}$ .
- Students should use Figure 9.8 on page 359 to make a graphic organizer for treating drinking water and Figure 9.11 for the main steps of treating waste water.
- Osmosis refers to the movement of materials from a high concentration to a lower concentration. Reverse osmosis would move materials in the opposite direction from low to high concentration. Waste materials which are found in low concentrations in water could be removed from water using this process. Students should access the websites for water softening companies who use reverse osmosis to make their drinking water taps.

## Chapter 9 Review Answers

### Student Textbook pages 365–367

### Answers to Knowledge and Understanding Questions

- "Spectator ions" do not participate in the reaction. They remain in solution. "Net ionic equation" outlines the ions that form a precipitate or gas as a result of reacting together.
- $\text{Al}^{3+}_{(\text{aq})} + 3 \text{OH}^{-}_{(\text{aq})} \rightarrow \text{Al}(\text{OH})_{3(\text{s})}$  Spectator ions:  $\text{NH}_4^+$ ,  $\text{NO}_3^-$
- $2 \text{H}^+_{(\text{aq})} + \text{S}^{2-}_{(\text{aq})} \rightarrow \text{H}_2\text{S}_{(\text{g})}$  Spectator ions:  $\text{Na}^+$ ,  $\text{SO}_4^{2-}$

4. (a)  $3 \text{Cu}^{2+}_{(\text{aq})} + 2 \text{PO}_4^{3-}_{(\text{aq})} \rightarrow \text{Cu}_3(\text{PO}_4)_2(\text{s})$  Spectator ions:  $\text{NH}_4^+$ ,  $\text{Cl}^-$   
 (b)  $\text{Al}^{3+}_{(\text{aq})} + 3 \text{OH}^-_{(\text{aq})} \rightarrow \text{Al}(\text{OH})_3(\text{s})$  Spectator ions:  $\text{Ba}^{2+}$ ,  $\text{NO}_3^-$   
 (c)  $\text{Mg}^{2+}_{(\text{aq})} + 2 \text{OH}^-_{(\text{aq})} \rightarrow \text{Mg}(\text{OH})_2(\text{s})$  Spectator ions:  $\text{Na}^+$ ,  $\text{Cl}^-$
5. (a)  $\text{Ag}^+_{(\text{aq})} + \text{Br}^-_{(\text{aq})} \rightarrow \text{AgBr}(\text{s})$ ;  $\text{Cu}^+_{(\text{aq})} + \text{Br}^-_{(\text{aq})} \rightarrow \text{CuBr}(\text{s})$ ;  
 $\text{Pb}^{2+}_{(\text{aq})} + \text{Br}^-_{(\text{aq})} \rightarrow \text{PbBr}_2(\text{s})$   
 (b)  $\text{Ca}^{2+}_{(\text{aq})} + \text{CO}_3^{2-}_{(\text{aq})} \rightarrow \text{CaCO}_3(\text{s})$ ;  $\text{Cu}^{2+}_{(\text{aq})} + \text{CO}_3^{2-}_{(\text{aq})} \rightarrow \text{CuCO}_3(\text{s})$ ;  
 $\text{Fe}^{2+}_{(\text{aq})} + \text{CO}_3^{2-}_{(\text{aq})} \rightarrow \text{FeCO}_3(\text{s})$   
 (c)  $\text{Pb}^{2+}_{(\text{aq})} + 2\text{Br}^-_{(\text{aq})} \rightarrow \text{PbBr}_2(\text{s})$ ;  $\text{Pb}^{2+}_{(\text{aq})} + \text{CO}_3^{2-}_{(\text{aq})} \rightarrow \text{PbCO}_3(\text{s})$ ;  
 $\text{Pb}^{2+}_{(\text{aq})} + 2\text{OH}^-_{(\text{aq})} \rightarrow \text{Pb}(\text{OH})_2(\text{s})$   
 (d)  $\text{Fe}^{3+}_{(\text{aq})} + 3 \text{OH}^-_{(\text{aq})} \rightarrow \text{Fe}(\text{OH})_3(\text{s})$ ;  $2 \text{Fe}^{3+}_{(\text{aq})} + 3 \text{CO}_3^{2-}_{(\text{aq})} \rightarrow$   
 $\text{Fe}_2(\text{CO}_3)_3(\text{s})$ ;  $2\text{Fe}^{3+}_{(\text{aq})} + 3\text{S}^{2-}_{(\text{aq})} \rightarrow \text{Fe}_2\text{S}_3(\text{s})$
6. (a)  $2\text{Cr}^{3+}_{(\text{aq})} + 3 \text{S}^{2-}_{(\text{aq})} \rightarrow \text{Cr}_2\text{S}_3(\text{s})$   
 (b)  $\text{Ni}^{2+}_{(\text{aq})} + \text{S}^{2-}_{(\text{aq})} \rightarrow \text{NiS}(\text{s})$   
 (c)  $\text{Mn}^{4+}_{(\text{aq})} + 2 \text{S}^{2-}_{(\text{aq})} \rightarrow \text{MnS}_2(\text{s})$
7.  $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Fe}^{2+}$ ;  $\text{Cl}^-$ ,  $\text{F}^-$ ,  $\text{CO}_3^{2-}$ ; bedrock such as limestone, purification plants, industries.
8. Coarse screens remove large particles physically. Flocculation removes suspended particles chemically.
9. (a) Magnesium hydroxide is only slightly soluble and shaking it mixes the solid into a suspended state before pouring.  
 (b)  $2 \text{HCl}_{(\text{aq})} + \text{Mg}(\text{OH})_2(\text{s}) \rightarrow \text{MgCl}_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$ ;  $2 \text{H}^+_{(\text{aq})} + 2 \text{OH}^-_{(\text{aq})} \rightarrow 2 \text{H}_2\text{O}(\text{l})$
10. (a) Iron(III) sulfide,  $\text{Fe}_2\text{S}_3(\text{s})$   
 (b)  $2 \text{FeCl}_3(\text{aq}) + 3(\text{NH}_4)_2\text{S}(\text{aq}) \rightarrow 6 \text{NH}_4\text{Cl}(\text{aq}) + \text{Fe}_2\text{S}_3(\text{s})$   
 (c)  $2 \text{Fe}^{3+}_{(\text{aq})} + 3\text{S}^{2-}_{(\text{aq})} \rightarrow \text{Fe}_2\text{S}_3(\text{s})$

## Answers to Inquiry Questions

11. Barium chloride would precipitate barium sulphate as well as silver chloride, so you would have a mixture of these two precipitates. Use NaCl instead.  $\text{Ag}^+_{(\text{aq})} + \text{Cl}^-_{(\text{aq})} \rightarrow \text{AgCl}(\text{s})$
12. Copper(II) sulfide is formed.  $\text{Cu}^{2+}_{(\text{aq})} + \text{S}^{2-}_{(\text{aq})} \rightarrow \text{CuS}(\text{s})$
13.  $\frac{15 \text{ g MgSO}_4 \cdot 7\text{H}_2\text{O}}{4.0 \text{ L}} \times \frac{1 \text{ mol MgSO}_4 \cdot 7\text{H}_2\text{O}}{246.52 \text{ g MgSO}_4 \cdot 7\text{H}_2\text{O}} \times \frac{1 \text{ mol Mg}^{2+}}{1 \text{ mol MgSO}_4 \cdot 7\text{H}_2\text{O}} = 0.015 \text{ mol/L Mg}^{2+}$
14. (a) Moles of sucrose =  $7.37 \text{ g} \div 342.34 \text{ g/mol}$   
 $= 0.02153 \text{ mol} \div 0.125 \text{ L} = 0.172 \text{ mol/L}$   
 (b) Moles of  $(\text{NH}_4)_3\text{PO}_4$  =  $15.5 \text{ g} \div 149.12 \text{ g/mol}$   
 $= 0.1039 \text{ mol} \div 0.180 \text{ L} = 0.577 \text{ mol/L}$   
 (c) Moles of  $\text{C}_3\text{H}_8\text{O}_3$  =  $76.7 \text{ g} \div 92.11 \text{ g/mol} = 0.8327 \text{ mol} \div 1.20 \text{ L}$   
 $= 0.694 \text{ mol/L}$
15.  $\text{Ca}(\text{NO}_3)_2(\text{aq}) + \text{K}_2\text{SO}_4(\text{aq}) \rightarrow \text{CaSO}_4(\text{s}) + 2\text{KNO}_3(\text{aq})$   
 $\text{SO}_4^{2-} = 0.180 \text{ mol/L SO}_4^{2-} \times 0.200 \text{ L}$   
 $= 0.0360 \text{ mol SO}_4^{2-}$   
 $\text{Ca}^{2+} = 0.200 \text{ mol/L Ca}^{2+} \times 0.050 \text{ L}$   
 $= 0.0100 \text{ mol Ca}^{2+}$   
 Mol  $\text{SO}_4^{2-}$  used  
 $= 0.0100 \text{ mol Ca}^{2+} \times \frac{1 \text{ mol SO}_4^{2-}}{1 \text{ mol Ca}^{2+}} = 0.0100 \text{ mol SO}_4^{2-}$   
 Mol  $\text{SO}_4^{2-}$  remaining  
 $= (0.0360 \text{ mol} - 0.0100 \text{ mol}) \text{SO}_4^{2-} = 0.0260 \text{ mol SO}_4^{2-}$   
 Concentration =  $\frac{0.0260 \text{ mol SO}_4^{2-}}{(0.200 \text{ L} + 0.050 \text{ L})} = 0.104 \text{ mol/L SO}_4^{2-}$

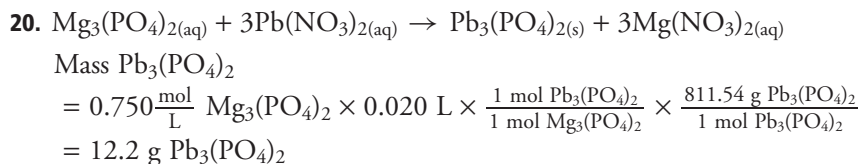
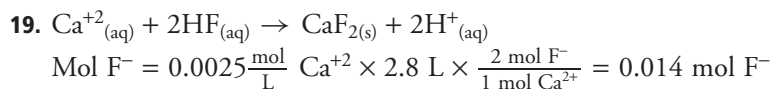
$$\begin{aligned}
 16. \text{ Concentration of } K^+ &= 0.200 \frac{\text{mol}}{\text{L}} K^+ \times 1.00 \text{ L} \times \frac{1}{3.00 \text{ L}} = 0.0667 \text{ mol/L } K^+ \\
 \text{Concentration of } Ca^{2+} &= 0.100 \frac{\text{mol}}{\text{L}} Ca^{2+} \times 2.00 \text{ L} \times \frac{1}{3.00 \text{ L}} = 0.0667 \text{ mol/L } Ca^{2+} \\
 \text{Mol } NO_3^- &= 0.100 \frac{\text{mol}}{\text{L}} Ca(NO_3)_2 \times 2.00 \text{ L} \times \frac{2 \text{ mol } NO_3^-}{1 \text{ mol } Ca(NO_3)_2} = 0.400 \text{ mol/L } NO_3^- \\
 \text{Mol } NO_3^- &= 0.200 \frac{\text{mol}}{\text{L}} KNO_3 \times 1.00 \text{ L} \times \frac{1 \text{ mol } NO_3^-}{1 \text{ mol } KNO_3} = 0.200 \text{ mol/L } NO_3^- \\
 \text{Concentration } NO_3^- &= \frac{(0.400 \text{ mol} + 0.200 \text{ mol})}{3.00 \text{ L}} NO_3^- = 0.200 \text{ mol/L } NO_3^-
 \end{aligned}$$

17. Assume 100 g of each solute is dissolved in 1.00 L of water.

$$\begin{aligned}
 \text{Concentration } Cl^- &= \frac{100 \text{ g NaCl}}{1.00 \text{ L}} \times \frac{1 \text{ mol NaCl}}{58.44 \text{ g NaCl}} \times \frac{1 \text{ mol } Cl^-}{1 \text{ mol NaCl}} = 1.71 \text{ mol/L } Cl^- \\
 \text{Concentration } Cl^- &= \frac{100 \text{ g } CaCl_2}{1.00 \text{ L}} \times \frac{1 \text{ mol } CaCl_2}{110.98 \text{ g } CaCl_2} \times \frac{2 \text{ mol } Cl^-}{1 \text{ mol } CaCl_2} = 1.80 \text{ mol/L } Cl^- \\
 \text{Concentration } Cl^- &= \frac{100 \text{ g } FeCl_3}{1.00 \text{ L}} \times \frac{1 \text{ mol } FeCl_3}{162.20 \text{ g } FeCl_3} \times \frac{3 \text{ mol } Cl^-}{1 \text{ mol } FeCl_3} = 1.85 \text{ mol/L } Cl^-
 \end{aligned}$$

Iron(III) chloride produces the largest chloride concentration of the three compounds.

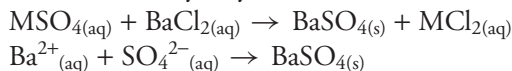
$$\begin{array}{ll}
 18. \text{ (a) Concentration } Ca^{+2} & \text{Concentration } Mg^{+2} \\
 = \frac{0.090 \text{ g } Ca^{2+}}{0.050 \text{ L}} \times \frac{1 \text{ mol } Ca^{2+}}{40.08 \text{ g } Ca^{2+}} & = \frac{0.029 \text{ g } Mg^{2+}}{0.050 \text{ L}} \times \frac{1 \text{ mol } Mg^{2+}}{24.31 \text{ g } Mg^{2+}} \\
 = 0.045 \text{ mol/L } Ca^{+2} & = 0.024 \text{ mol/L } Mg^{+2} \\
 \text{(b) ppm } Ca^{+2} & \text{ppm } Mg^{+2} \\
 = \frac{0.090 \text{ g } Ca^{2+}}{50 \text{ g } H_2O} \times 1\,000\,000 & = \frac{0.029 \text{ g } Mg^{2+}}{50 \text{ g } H_2O} \times 1\,000\,000 \\
 = 1\,800 \text{ ppm } Ca^{2+} & = 580 \text{ ppm } Mg^{2+}
 \end{array}$$



21. Add any cation except  $NH_4^+$  or group 1A to precipitate the phosphate group.

## Answers to Communication Questions

22. (a) Let M be the mystery metal.



$$\begin{aligned}
 \text{(b) Mole } SO_4^{2-} & \\
 = 2.468 \text{ g } BaSO_4 \times \frac{1 \text{ mol } BaSO_4}{233.4 \text{ g } BaSO_4} \times \frac{1 \text{ mol } SO_4^{2-}}{1 \text{ mol } BaSO_4} & \\
 = 0.01057 \text{ mol } SO_4^{2-} &
 \end{aligned}$$

$$\begin{aligned}
 \text{(c) Molar mass } MSO_4 & \\
 = \frac{1.273 \text{ g } MSO_4}{0.0105741 \text{ mol } MSO_4} & \\
 = 120.4 \text{ g/mol } MSO_4 &
 \end{aligned}$$

$$\begin{aligned}
 \text{(d) Mass } SO_4^{2-} & \\
 = 0.01057 \text{ mol } SO_4^{2-} \times \frac{96.07 \text{ g } SO_4^{2-}}{1 \text{ mol } SO_4^{2-}} & \\
 = 1.016 \text{ g } SO_4^{2-} & \\
 \text{Mass } M = 1.273 \text{ g } MSO_4 - 1.016 \text{ g } SO_4^{2-} &= 0.257144 \text{ g } M
 \end{aligned}$$

$$\text{Molar Mass } M = \frac{0.257144 \text{ g } M}{0.0105741 \text{ mol } M} = 24.32 \text{ g/mol } M$$

Therefore the metal is Mg.

In order to check, add sulphate which forms a soluble compound with magnesium but an insoluble compound with calcium. Another test would be a flame test giving a bright white light as opposed to calcium which gives a red-orange flame colour.

23. Assume 100 g of each salt in 1.00 L of water.

$$\begin{aligned} &\text{Concentration CO}_3^{2-} \\ &= \frac{100 \text{ g Rb}_2\text{CO}_3}{1 \text{ L}} \times \frac{1 \text{ mol Rb}_2\text{CO}_3}{230.95 \text{ g Rb}_2\text{CO}_3} \times \frac{1 \text{ mol CO}_3^{2-}}{1 \text{ mol Rb}_2\text{CO}_3} \\ &= 0.433 \text{ mol/L CO}_3^{2-} \end{aligned}$$

$$\begin{aligned} &\text{Concentration CO}_3^{2-} \\ &= \frac{100 \text{ g CaCO}_3}{1 \text{ L}} \times \frac{1 \text{ mol CaCO}_3}{100.09 \text{ g CaCO}_3} \times \frac{1 \text{ mol CO}_3^{2-}}{1 \text{ mol CaCO}_3} \\ &= 0.999 \text{ mol/L CO}_3^{2-} \end{aligned}$$

CaCO<sub>3</sub> yields the higher CO<sub>3</sub><sup>2-</sup> ion concentration.

24. (a)  $\text{Ag}^+(\text{aq}) + \text{NaCl}(\text{aq}) \rightarrow \text{AgCl}(\text{s}) + \text{Na}^+(\text{aq})$  The excess nitric acid caused the silver to dissociate from the ore so that it could be available to precipitate as a chloride.

(b) Mass Ag

$$\begin{aligned} &= 1.092 \text{ g AgCl} \times \frac{1 \text{ mol AgCl}}{143.32 \text{ g AgCl}} \times \frac{1 \text{ mol Ag}}{1 \text{ mol AgCl}} \times \frac{107.87 \text{ g Ag}}{1 \text{ mol Ag}} \\ &= 0.8219 \text{ g Ag} \end{aligned}$$

$$\% \text{ Ag} = \frac{0.8219 \text{ g Ag}}{856.1 \text{ g ore}} \times 100\% = 0.096\% \text{ Ag in the ore.}$$

Therefore, the prospector should celebrate.

## Answers to Making Connections Questions

25. Showering or bathing, using dishwashers, and washing clothes might be suggested. Some countries where pure clean water is difficult to obtain already do have two different water supplies. This would certainly save money as far as water purification is concerned. Washing cars, clothes and watering gardens could be done with water that is less pure than that which would be required for cooking and drinking.
26. Paint containing oil based solvents, batteries containing heavy metals, and insoluble solvents such as varsol could contaminate landfills. Communities have special garbage pickups for many of these materials and they can also be taken to special places where toxic chemicals are disposed of safely. Paint cans can be left open to dry and then can be disposed of in the regular trash.
27. Answers will vary.