Pearson

Exercises

Review Questions

1. What is an aqueous solution? What is the difference between the solute and the solvent?
2. What is molarity? How is it useful?
3. Explain how a strong electrolyte, a weak electrolyte, and a nonelectrolyte differ.
4. What is an acid? Explain the difference between a strong acid and a weak acid.
5. What does it mean for a compound to be soluble? Insoluble?
6. What are the solubility rules? How are they useful?
7. Which cations and anions form compounds that are usually soluble? What are the exceptions? Which anions form compounds that are mostly insoluble? What are the exceptions?
8. What is a precipitation reaction? Give an example.
9. How can you predict whether a precipitation reaction will occur upon mixing two aqueous solutions?
10. Explain how a molecular equation, a complete ionic equation, and a net ionic equation differ.
11. What is the Arrhenius definition of a base?
12. Explain how to name binary acids and oxyacids.
13. What is an acid–base reaction? Provide an example.
14. Explain the principles behind an acid–base titration. What is an indicator?
15. What is a gas-evolution reaction? Provide an example.
16. Which reactant types give rise to gas-evolution reactions?
17. What is an oxidation–reduction reaction? Provide an example.
18. What are oxidation states? How can oxidation states be used to identify redox reactions?
19. What happens to a substance when it becomes oxidized? Reduced?
20. In a redox reaction, which reactant is the oxidizing agent? The reducing agent?

Problems by Topic

Note: Answers to all odd-numbered Problems can be found in Appendix III. Exercises in the Problems by Topic section are paired, with each odd-numbered problem followed by a similar even-numbered problem. Exercises in the Cumulative Problems section are also paired but somewhat more loosely. Because of their nature, Challenge Problems and Conceptual Problems, are unpaired.

Solution Concentration and Solution Stoichiometry

21. Calculate the molarity of each solution.
    - a. 3.25 mol of LiCl in 2.78 L solution
    - b. 28.33 g $C_6H_{12}O_6$ in 1.28 L of solution
    - c. 32.4 mg NaCl in 122.4 mL of solution
22. Calculate the molarity of each solution.
    - a. 0.38 mol of $LiNO_3$ in 6.14 L of solution

b. 72.8 g C_2H_6O in 2.34 L of solution

c. 12.87 mg KI in 112.4 mL of solution

23. What is the molarity of NO_3^- in each solution?

a. 0.150 M KNO_3

b. 0.150 M $Ca(NO_3)_2$

c. 0.150 M $Al(NO_3)_3$

24. What is the molarity of Cl^- in each solution?

a. 0.200 M NaCl

b. 0.150 M $SrCl_2$

c. 0.100 M $AlCl_3$

25. How many moles of KCl are contained in each solution?

a. 0.556 L of a 2.3 M KCl solution

b. 1.8 L of a 0.85 M KCl solution

c. 114 mL of a 1.85 M KCl solution

26. What volume of 0.200 M ethanol solution contains each of the following amounts?

a. 0.45 mol ethanol

b. 1.22 mol ethanol

c. 1.2×10^{-2} mol ethanol

27. A laboratory procedure calls for making 400.0 mL of a 1.1 M $NaNO_3$ solution. What mass of $NaNO_3$ (in g) do you need?

28. A chemist wants to make 5.5 L of a 0.300 M $CaCl_2$ solution. What mass of $CaCl_2$ (in g) should the chemist use?

29. If 123 mL of a 1.1 M glucose solution is diluted to 500.0 mL, what is the molarity of the diluted solution?

30. If 3.5 L of a 4.8 M $SrCl_2$ solution is diluted to 45 L, what is the molarity of the diluted solution?

31. To what volume should you dilute 50.0 mL of a 12 M stock HNO_3 solution to obtain a 0.100 M HNO_3 solution?

32. To what volume should you dilute 25 mL of a 10.0 M H_2SO_4 solution to obtain a 0.150 M H_2SO_4 solution?

33. Consider the precipitation reaction:

$$2\ Na_3PO_4\,(aq) + 3\ CuCl_2\,(aq) \rightarrow Cu_3(PO_4)_2\,(s) + 6\ NaCl\,(aq)$$

What volume of 0.175 M Na_3PO_4 solution is necessary to completely react with 95.4 mL of 0.102 M $CuCl_2$?

34. Consider the reaction:

$$Li_2S(aq) + Co(NO_3)_2\,(aq) \rightarrow 2\ LiNO_3\,(aq) + CoS\,(s)$$

What volume of 0.150 M Li_2S solution is required to completely react with 125 mL of 0.150 M $Co(NO_3)_2$?

35. What is the minimum amount of 6.0 M H_2SO_4 necessary to produce 25.0 g of $H_2\,(g)$ according to the reaction between aluminum and sulfuric acid?

$$2\ Al\,(s) + 3\ H_2SO_4\,(aq) \rightarrow Al_2(SO_4)_3\,(aq) + 3\ H_2\,(g)$$

36. What molarity of $ZnCl_2$ forms when 25.0 g of zinc completely reacts with $CuCl_2$ according to the following reaction? Assume a final volume of 275 mL.

$$Zn\,(s) + CuCl_2\,(aq) \rightarrow ZnCl_2\,(aq) + Cu\,(s)$$

37. You mix a 25.0 mL sample of a 1.20 M potassium chloride solution with 15.0 mL of a 0.900 M barium nitrate solution, and this precipitation reaction occurs:

$$2\ \mathrm{KCl}\,(aq) + \mathrm{Ba(NO_3)_2}\,(aq) \rightarrow \mathrm{BaCl_2}\,(s) + 2\ \mathrm{KNO_3}\,(aq)$$

You collect and dry the solid $BaCl_2$ and find it has a mass of 2.45 g. Determine the limiting reactant, the theoretical yield, and the percent yield.

38. You mix a 55.0 mL sample of a 0.102 M potassium sulfate solution with 35.0 mL of a 0.114 M lead acetate solution, and this precipitation reaction occurs:

$$\mathrm{K_2SO_4}\,(aq) + \mathrm{Pb(C_2H_3O_2)_2}\,(aq) \rightarrow 2\ \mathrm{KC_2H_3O_2}\,(aq) + \mathrm{PbSO_4}\,(s)$$

You collect and dry the solid $PbOS_4$ and find it has a mass of 1.01 g. Determine the limiting reactant, the theoretical yield, and the percent yield.

Types of Aqueous Solutions and Solubility

39. For each compound (all water soluble), would you expect the resulting aqueous solution to conduct electrical current?

- **a.** $CsCl$
- **b.** CH_3OH
- **c.** $Ca(NO_2)_2$
- **d.** $C_6H_{12}O_6$

40. Classify each compound as a strong electrolyte or nonelectrolyte.

- **a.** $MgBr_2$
- **b.** $C_{12}H_{22}O_{11}$
- **c.** Na_2CO_3
- **d.** KOH

41. Determine whether each compound is soluble or insoluble. If the compound is soluble, list the ions present in solution.

- **a.** $AgNO_3$
- **b.** $Pb(C_2H_3O_2)_2$
- **c.** KNO_3
- **d.** $(NH_4)_2S$

42. Determine whether each compound is soluble or insoluble. For the soluble compounds, list the ions present in solution.

- **a.** AgI
- **b.** $Cu_3(PO_4)_2$
- **c.** $CoCO_3$
- **d.** K_3PO_4

Precipitation Reactions

43. Complete and balance each equation. If no reaction occurs, write NO REACTION.

- **a.** $\mathrm{LiI}\,(aq) + \mathrm{BaS}\,(aq) \rightarrow$
- **b.** $\mathrm{KCl}\,(aq) + \mathrm{CaS}\,(aq) \rightarrow$
- **c.** $\mathrm{CrBr_2}\,(aq) + \mathrm{Na_2CO_3}\,(aq) \rightarrow$
- **d.** $\mathrm{NaOH}\,(aq) + \mathrm{FeCl_3}\,(aq) \rightarrow$

44. Complete and balance each equation. If no reaction occurs, write NO REACTION.

- **a.** $\mathrm{NaNO_3}\,(aq) + \mathrm{KCl}\,(aq) \rightarrow$
- **b.** $\mathrm{NaCl}\,(aq) + \mathrm{Hg_2(C_2H_3O_2)_2}\,(aq) \rightarrow$
- **c.** $\mathrm{(NH_4)_2SO_4}\,(aq) + \mathrm{SrCl_2}\,(aq) \rightarrow$
- **d.** $\mathrm{NH_4Cl}\,(aq) + \mathrm{AgNO_3}\,(aq) \rightarrow$

45. Write a molecular equation for the precipitation reaction that occurs (if any) when each pair of aqueous solutions is mixed. If no reaction occurs, write NO REACTION.

- **a.** potassium carbonate and lead(II) nitrate
- **b.** lithium sulfate and lead(II) acetate

   c. copper(II) nitrate and magnesium sulfide
   d. strontium nitrate and potassium iodide

46. Write a molecular equation for the precipitation reaction that occurs (if any) when each pair of aqueous solutions is mixed. If no reaction occurs, write NO REACTION.
   a. sodium chloride and lead(II) acetate
   b. potassium sulfate and strontium iodide
   c. cesium chloride and calcium sulfide
   d. chromium(III) nitrate and sodium phosphate

Ionic and Net Ionic Equations

47. Write balanced complete ionic and net ionic equations for each reaction.
   a. $HCl\,(aq) + LiOH\,(aq) \rightarrow H_2O\,(l) + LiCl\,(aq)$
   b. $MgS\,(aq) + CuCl_2\,(aq) \rightarrow CuS\,(s) + MgCl_2\,(aq)$
   c. $NaOH\,(aq) + HNO_3\,(aq) \rightarrow H_2O\,(l) + NaNO_3\,(aq)$
   d. $Na_3PO_4\,(aq) + NiCl_2\,(aq) \rightarrow Ni_3(PO_4)_2\,(s) + NaCl\,(aq)$

48. Write balanced complete ionic and net ionic equations for each reaction.
   a. $K_2SO_4\,(aq) + CaI_2\,(aq) \rightarrow CaSO_4\,(s) + KI\,(aq)$
   b. $NH_4Cl\,(aq) + NaOH\,(aq) \rightarrow H_2O\,(l) + NH_3\,(g) + NaCl\,(aq)$
   c. $AgNO_3\,(aq) + NaCl\,(aq) \rightarrow AgCl\,(s) + NaNO_3\,(aq)$
   d. $HC_2H_3O_2\,(aq) + K_2CO_3\,(aq) \rightarrow H_2O\,(l) + CO_2\,(g) + KC_2H_3O_2\,(aq)$

49. Mercury ions $\left(Hg_2{}^{2+}\right)$ can be removed from solution by precipitation with Cl^-. Suppose that a solution contains aqueous $Hg_2(NO_3)_2$ Write complete ionic and net ionic equations to show the reaction of aqueous $Hg_2(NO_3)_2$with aqueous sodium chloride to form solid Hg_2Cl_2 and aqueous sodium nitrate.

50. Lead ions can be removed from solution by precipitation with sulfate ions. Suppose that a solution contains lead(II) nitrate. Write complete ionic and net ionic equations to show the reaction of aqueous lead(II) nitrate with aqueous potassium sulfate to form solid lead(II) sulfate and aqueous potassium nitrate.

Naming Acids

51. Name each acid.
   a. $HI(aq)$
   b. $HNO_3\,(aq)$
   c. $H_2CO_3\,(aq)$

52. Name each acid.
   a. $HCl(aq)$
   b. $HClO_2\,(aq)$
   c. $H_2SO_4\,(aq)$

53. Provide the formula for each acid.
   a. hydrofluoric acid
   b. hydrobromic acid
   c. sulfurous acid

54. Provide the formula for each acid.
   a. phosphoric acid
   b. hydrocyanic acid
   c. chlorous acid

Acid–Base Reactions

55. Write balanced molecular and net ionic equations for the reaction between hydrobromic acid and potassium hydroxide.

56. Write balanced molecular and net ionic equations for the reaction between nitric acid and

56. Write balanced molecular and net ionic equations for the reaction between nitric acid and calcium hydroxide.

57. Complete and balance each acid–base equation.

- **a.** $H_2SO_4\,(aq) + Ca(OH)_2\,(aq) \rightarrow$
- **b.** $HClO_4\,(aq) + KOH\,(aq) \rightarrow$
- **c.** $H_2SO_4\,(aq) + NaOH\,(aq) \rightarrow$

58. Complete and balance each acid–base equation.

- **a.** $HI\,(aq) + LiOH\,(aq) \rightarrow$
- **b.** $HC_2H_3O_2\,(aq) + Ca(OH)_2\,(aq) \rightarrow$
- **c.** $HCl\,(aq) + Ba(OH)_2\,(aq) \rightarrow$

59. Write balanced complete ionic and net ionic equations for each acid–base reaction.

- **a.** $HBr\,(aq) + NaOH\,(aq) \rightarrow$
- **b.** $HF\,(aq) + NaOH\,(aq) \rightarrow$
- **c.** $HC_2H_3O_2\,(aq) + RbOH\,(aq) \rightarrow$

60. Write balanced complete ionic and net ionic equations for each acid–base reaction.

- **a.** $HI\,(aq) + RbOH\,(aq) \rightarrow$
- **b.** $HCHO_2\,(aq) + NaOH\,(aq) \rightarrow$
- **c.** $HC_2H_3O_2\,(aq) + LiOH\,(aq) \rightarrow$

61. A 25.00-mL sample of an unknown $HClO_4$ solution requires titration with 22.62 mL of 0.2000 M NaOH to reach the equivalence point. What is the concentration of the unknown $HClO_4$ solution? The neutralization reaction is:

$$HClO_4\,(aq) + NaOH\,(aq) \rightarrow H_2O\,(l) + NaClO_4\,(aq)$$

62. A 30.00-mL sample of an unknown H_3PO_4 solution is titrated with a 0.100 M NaOH solution. The equivalence point is reached when 26.38 mL of NaOH solution is added. What is the concentration of the unknown H_3PO_4 solution? The neutralization reaction is:

$$H_3PO_4\,(aq) + 3\,NaOH\,(aq) \rightarrow 3\,H_2O\,(l) + Na_3PO_4\,(aq)$$

Gas-Evolution Reactions

63. Complete and balance each gas-evolution equation.

- **a.** $HBr\,(aq) + NiS\,(s) \rightarrow$
- **b.** $NH_4I\,(aq) + NaOH\,(aq) \rightarrow$
- **c.** $HBr\,(aq) + Na_2S\,(aq) \rightarrow$

64. Complete and balance each gas-evolution equation.

- **a.** $HCl\,(aq) + KHCO_3\,(aq) \rightarrow$
- **b.** $HC_2H_3O_2\,(aq) + NaHSO_3\,(aq) \rightarrow$
- **c.** $(NH_4)_2SO_4\,(aq) + Ca(OH)_2\,(aq) \rightarrow$

65. Write a balanced equation for the reaction between perchloric acid and lithium carbonate.

66. Write a balanced equation for the reaction between nitric acid and sodium sulfite.

Oxidation and Reduction

67. Assign oxidation states to each atom in each element, ion, or compound.

- **a.** Ag
- **b.** Ag^+
- **c.** CaF_2
- **d.** H_2S
- **e.** $CO_3^{\,2-}$
- **f.** $CrO_4^{\,2-}$

68. Assign oxidation states to each atom in each element, ion, or compound.

- **a.** Cl_2
- **b.** Fe^{3+}

b. Fe^{3+}

c. $CuCl_2$

d. CH_4

e. $Cr_2O_7{}^{2-}$

f. $HSO_4{}^-$

69. What is the oxidation state of Cr in each compound?

a. CrO

b. CrO_3

c. Cr_2O_3

70. What is the oxidation state of Cl in each ion?

a. ClO^-

b. $ClO_2{}^-$

c. $ClO_3{}^-$

d. $ClO_4{}^-$

71. Determine whether or not each reaction is a redox reaction. For each redox reaction, identify the oxidizing agent and the reducing agent.

a. $4\ Li\,(s) + O_2\,(g) \rightarrow 2\ Li_2O\,(s)$

b. $Mg\,(s) + Fe^{2+}\,(aq) \rightarrow Mg^{2+}\,(aq) + Fe\,(s)$

c. $Pb(NO_3)_2\,(aq) + Na_2SO_4\,(aq) \rightarrow PbSO_4\,(s) + 2\ NaNO_3\,(aq)$

d. $HBr\,(aq) + KOH\,(aq) \rightarrow H_2O\,(l) + KBr\,(aq)$

72. Determine whether or not each reaction is a redox reaction. For each redox reaction, identify the oxidizing agent and the reducing agent.

a. $Al\,(s) + 3\ Ag^+\,(aq) \rightarrow Al^{3+}\,(aq) + 3\ Ag\,(s)$

b. $SO_3\,(g) + H_2O\,(l) \rightarrow H_2SO_4\,(aq)$

c. $Ba\,(s) + Cl_2\,(g) \rightarrow BaCl_2\,(s)$

d. $Mg\,(s) + Br_2\,(l) \rightarrow MgBr_2\,(s)$

73. Determine whether each redox reaction occurs spontaneously in the forward direction.

a. $Ni\,(s) + Zn^{2+}\,(aq) \rightarrow Ni^{2+}\,(aq) + Zn\,(s)$

b. $Ni\,(s) + Pb^{2+}\,(aq) \rightarrow Ni^{2+}\,(aq) + Pb\,(s)$

c. $Al\,(s) + 3\ Ag^+\,(aq) \rightarrow 3\ Al^{3+}\,(aq) + Ag\,(s)$

d. $Pb\,(s) + Mn^{2+}\,(aq) \rightarrow Pb^{2+}\,(aq) + Mn\,(s)$

74. Determine whether each redox reaction occurs spontaneously in the forward direction.

a. $Ca^{2+}\,(aq) + Zn\,(s) \rightarrow Ca\,(s) + Zn^{2+}\,(aq)$

b. $2\ Ag^+\,(aq) + Ni\,(s) \rightarrow 2\ Ag\,(s) + Ni^{2+}\,(aq)$

c. $Fe\,(s) + Mn^{2+}\,(aq) \rightarrow Fe^{2+}\,(aq) + Mn\,(s)$

d. $2\ Al\,(s) + 3\ Pb^{2+}\,(aq) \rightarrow 2\ Al^{3+}\,(aq) + 3\ Pb\,(s)$

75. Suppose you wanted to cause Ni^{2+} ions to come out of solution as solid Ni. Which metal could you use to accomplish this?

76. Suppose you wanted to cause Pb^{2+} ions to come out of solution as solid Pb. Which metal could you use to accomplish this?

77. Which metal in the activity series reduces Al^{3+} ions but not Na^+ ions?

78. Which metal in the activity series is oxidized with a Ni^{2+} solution but not with a Cr^{3+} solution?

Cumulative Problems

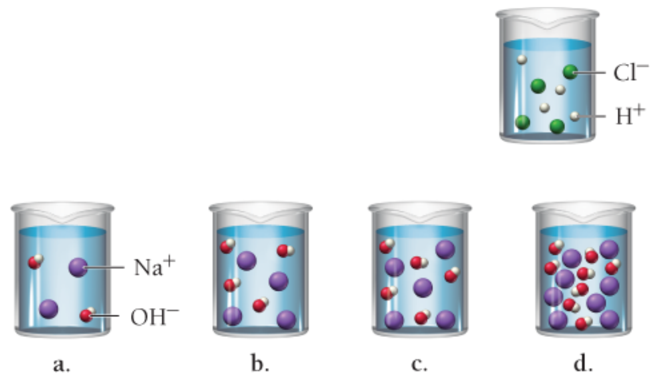
79. The density of a 20.0% by mass ethylene glycol $(C_2H_6O_2)$solution in water is 1.03 g/mL. Find the molarity of the solution.

80. Find the percent by mass of sodium chloride in a 1.35 M NaCl solution. The density of the solution is 1.05 g/mL.

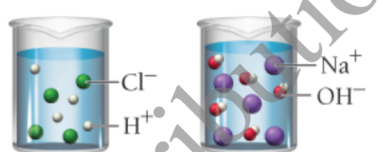
81. People often use sodium bicarbonate as an antacid to neutralize excess hydrochloric acid in an upset stomach. What mass of hydrochloric acid (in grams) can 2.5 g of sodium bicarbonate neutralize? *(Hint:* Begin by writing a balanced equation for the reaction between aqueous sodium bicarbonate and aqueous hydrochloric acid.)

82. Toilet bowl cleaners often contain hydrochloric acid, which dissolves the calcium carbonate deposits that accumulate within a toilet bowl. What mass of calcium carbonate (in grams) can 3.8 g of HCl dissolve? (*Hint:* Begin by writing a balanced equation for the reaction between hydrochloric acid and calcium carbonate.)

83. A hydrochloric acid solution will neutralize a sodium hydroxide solution. Consider these molecular views of one beaker of HCl and four beakers of NaOH. Which NaOH beaker will just neutralize the HCl beaker? Begin by writing a balanced chemical equation for the neutralization reaction.



84. These two beakers represent solutions of HCl and NaOH. Draw a third beaker showing the ions that remain after the reaction has gone to completion.



85. Predict the products and write a balanced molecular equation for each reaction. If no reaction occurs, write NO REACTION.

- **a.** $HCl\,(aq) + Hg_2(NO_3)_2\,(aq) \rightarrow$
- **b.** $KHSO_3\,(aq) + HNO_3\,(aq) \rightarrow$
- **c.** aqueous ammonium chloride and aqueous lead(II) nitrate
- **d.** aqueous ammonium chloride and aqueous calcium hydroxide

86. Predict the products and write a balanced molecular equation for each reaction. If no reaction occurs, write NO REACTION.

- **a.** $H_2SO_4\,(aq) + HNO_3\,(aq) \rightarrow$
- **b.** $Cr(NO_3)_3\,(aq) + LiOH\,(aq) \rightarrow$
- **c.** liquid pentanol $(C_5H_{12}O)$and gaseous oxygen
- **d.** aqueous strontium sulfide and aqueous copper(II) sulfate

87. Hard water often contains dissolved Ca^{2+} and Mg^{2+} ions. One way to soften water is to add phosphates. The phosphate ion forms insoluble precipitates with calcium and magnesium ions, removing them from solution. A solution is 0.050 M in calcium chloride and 0.085 M in magnesium nitrate. What mass of sodium phosphate would have to be added to 1.5 L of this solution to completely eliminate the hard water ions? Assume a complete reaction.

88. An acid solution is 0.100 M in HCl and 0.200 M in H_2SO_4. What volume of a 0.150 M KOH solution would completely neutralize all the acid in 500.0 mL of this solution?

89. Find the mass of barium metal (in grams) that must react with O_2 to produce enough barium oxide to prepare 1.0 L of a 0.10 M solution of OH^-. (*Hint:* Barium metal reacts with oxygen to form BaO; BaO reacts with water to form $Ba(OH)_2$)

90. A solution contains Cr^{3+} ion and Mg^{2+} ion. The addition of 1.00 L of 1.51 M NaF solution causes the complete precipitation of these ions as $CrF_3\,(s)$and $MgF_2\,(s)$. The total mass of the precipitate is 49.6 g. Find the mass of Cr^{3+} in the original solution.

91. Find the volume of 0.110 M hydrochloric acid necessary to react completely with 1.52 g $Al(OH)_3$.

92. Find the volume of 0.150 M sulfuric acid necessary to react completely with 75.3 g sodium hydroxide.

93. Treatment of gold metal with BrF_3 and KF produces Br_2 and $KAuF_4$, a salt of gold. Identify the oxidizing agent and the reducing agent in this reaction. What mass of the gold salt forms when a 73.5-g mixture of equal masses of all three reactants is prepared?

94. We prepare a solution by mixing 0.10 L of 0.12 M sodium chloride with 0.23 L of a 0.18 M $MgCl_2$ solution. What volume of a 0.20 M silver nitrate solution do we need to precipitate all the Cl^- ion in the solution as AgCl?

Challenge Problems

95. A solution contains Ag^+ and Hg^{2+} ions. The addition of 0.100 L of 1.22 M NaI solution is just enough to precipitate all the ions as AgI and HgI_2. The total mass of the precipitate is 28.1 g. Find the mass of AgI in the precipitate.

96. The water in lakes that have been acidified by acid rain (HNO_3 and H_2SO_4) can be neutralized by a process called liming, in which limestone ($CaCO_3$)is added to the acidified water. What mass of limestone (in kg) will completely neutralize a 15.2 billion-liter lake that is 1.8×10^{-5} Min H_2SO_4 and 8.7×10^{-6} Min HNO_3?

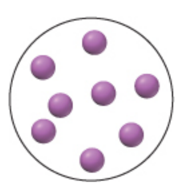
97. Recall from Section 8.5 that sodium carbonate is often added to laundry detergents to soften hard water and make the detergent more effective. Suppose that a particular detergent mixture is designed to soften hard water that is 3.5×10^{-3} Mn Ca^{2+} and 1.1×10^{-3} Min Mg^{2+} and that the average capacity of a washing machine is 19.5 gallons of water. If 0.65 kg detergent is required per load of laundry, what percentage (by mass) of the detergent should be sodium carbonate in order to completely precipitate all of the calcium and magnesium ions in an average load of laundry water?

98. A solution contains one or more of the following ions: Ag^+, Ca^{2+}, and Cu^{2+}. When you add sodium chloride to the solution, no precipitate forms. When you add sodium sulfate to the solution, a white precipitate forms. You filter off the precipitate and add sodium carbonate to the remaining solution, producing another precipitate. Which ions were present in the original solution? Write net ionic equations for the formation of each of the precipitates observed.

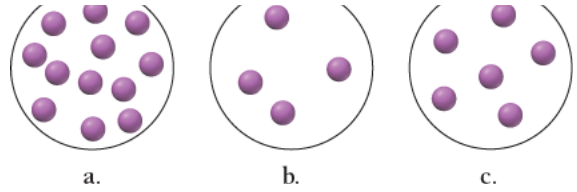
99. A solution contains one or more of the following ions: $Hg_2^{\ 2+}$, Ba^{2+}, and Fe^{2+}. When potassium chloride is added to the solution, a precipitate forms. The precipitate is filtered off, and potassium sulfate is added to the remaining solution, producing no precipitate. When potassium carbonate is added to the remaining solution, a precipitate forms. Which ions were present in the original solution? Write net ionic equations for the formation of each of the precipitates observed.

Conceptual Problems

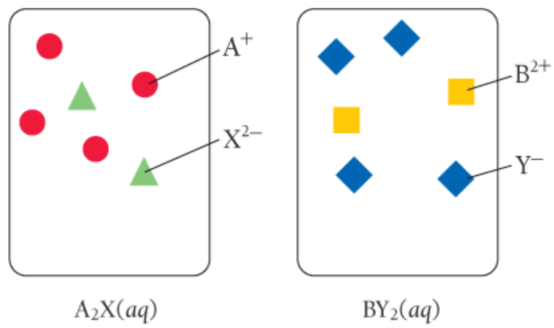
100. The circle shown here represents 1.0 L of a solution with a solute concentration of 1 M:



Explain what you would add (the amount of solute or volume of solvent) to the solution to obtain a solution represented by each diagram:



101. Consider the generic ionic compounds with the formulas A_2X and BY_2 and the following solubility rules: A_2X soluble; BY_2 soluble; AY insoluble; BX soluble. Let circles represent A^+ ions, squares represent B^{2+} ions, triangles represent X^{2-} ions, and diamonds represent Y^- ions. Solutions of the two compounds (A_2X and BY_2) can be represented as follows:



Draw a molecular-level representation showing the result of mixing the two solutions (A_2X and BY_2) and write an equation to represent the reaction.

102. If you dissolve 27 g of sugar into 155 mL of water, what can you conclude about the mass and volume of the resulting solution? Assume a density of 1.00 g/mL for the water.

- **a.** mass = 155 g; volume = 155 mL
- **b.** mass = 182 g; volume = 155 mL
- **c.** mass = 182 g; volume > 155 mL
- **d.** mass = 155 g; volume > 155 mL

103. Explain the difference between the charge of an ion, such as a charge of 2− for an O^{2-} ion, and the oxidation state of an atom, such as the −4 oxidation state of carbon in CH_4.

Questions for Group Work

Active Classroom Learning

Discuss these questions with the group and record your consensus answer.

104. Write a detailed set of instructions for making two solutions: (1) 100.0 mL of 12-M NaOH from solid sodium hydroxide and (2) 1.00 L of 0.1 M NaOH from your first solution. You have in your lab: volumetric flasks marked to contain 100.0 mL and 1.000 L, a graduated cylinder, and a balance.

105. Review the solubility rules. Without referring back to the rules, have each group member list two ionic compounds that are expected to be soluble and two that are expected to be insoluble. Include at least one exception. Check the work of the other members of your group.

106. Define and give an example of each of the following classes of reactions: precipitation, acid–base, gas evolution, redox (noncombustion), and combustion. Each group member can do one and then present the reaction to the group.

107. Using group members to represent atoms, ions, or electrons, act out the reaction $Zn(s) + Fe^{2+}(aq) \rightarrow Zn^{2+}(aq) + Fe(s)$. Which group member is oxidized? Which is reduced? Which is the oxidizing agent? Which is the reducing agent?

Data Interpretation and Analysis

108. In April 2014, in an effort to save money, officials in Flint, Michigan, changed their water source from Lake Huron to the Flint River. In subsequent months, residents began complaining about the quality of the water, and General Motors (which has an engine plant in Flint) stopped using the water in manufacturing because of its corrosiveness. That corrosiveness was causing problems that would soon fuel a national outrage. The water flowed through pipes to taps in homes, and as it flowed through the pipes, many of which contained lead, the corrosive water became contaminated with lead. Routine monitoring of the tap water in select homes did not reveal the magnitude of the problem because samples were collected only after preflushing the tap (allowing the water to run for a time).

A Virgina Tech professor and his students began an independent test of the water coming from Flint's taps and got much different results by analyzing the water that initially came from the taps (first draw). Their results—which showed elevated lead levels in the tap water—ultimately forced officials to switch back to the Lake Huron water source.

The following table shows a set of data collected by the Virginia Tech team. The lead levels in water are expressed in units of parts per billion (ppb). 1 ppb = 1 g $\text{Pb}/10^9$ parts solution. Examine the data and answer the questions that follow.

Lead Levels in Samples of Flint Tap Water

Sample #	Lead Level 1st draw (ppb)	Lead Level 45 sec flush (ppb)	Lead Level 2 min flush (ppb
1	0.344	0.226	0.145
2	8.133	10.77	2.761
3	1.111	0.11	0.123
4	8.007	7.446	3.384
5	1.951	0.048	0.035
6	7.2	1.4	0.2
7	40.63	9.726	6.132
8	1.1	2.5	0.1
9	10.6	1.038	1.294
10	6.2	4.2	2.3
11	4.358	0.822	0.147
12	24.37	8.796	4.347
13	6.609	5.752	1.433
14	4.062	1.099	1.085
15	29.59	3.258	1.843

Source: FlintWaterStudy.org (2015) "Lead Results from Tap Water Sampling in Flint, Michigan, during the Flint Water Crisis"

a. Determine the average value of lead for first draw, 45-second flush, and 2-minute flush (round to three significant figures).

b. Do the data support the idea that running the tap water before taking a sample made the lead levels in the water appear lower? Why might this occur?

c. The EPA requires water providers to monitor drinking water at customer taps. If lead concentrations exceed 15 ppm in 10% or more of the taps sampled, the water provider must notify the customer and take steps to control the corrosiveness of the water. If the water provider in Flint had used first-draw samples to monitor lead levels, would they have been required to take action by EPA requirements? If the Flint water provider used 2-min flush samples, would they have had to take action? Which drawing technique do you think more closely mimics the way residents actually use their water?

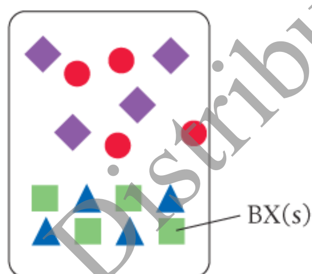
d. Using the highest value of lead from the first-draw data set, and assuming a resident drinks 2 L of water per day, calculate the mass of lead that the resident would consume over the course of one year. (Assume the water has a density of 1.0 g/mL.)

Answers to Conceptual Connections

Cc 8.1 (b) The mass of a solution is equal to the mass of the solute plus the mass of the solvent. Although the solute seems to disappear, it really does not, and its mass becomes part of the mass of the solution, in accordance with the law of mass conservation.

Cc 8.2 (c) Because the volume has doubled, the concentration is halved, so the same volume should contain half as many solute molecules.

Cc 8.3 A is the limiting reactant. There are equal amounts of both reactants, but the reaction requires twice as much A as B.



$$AX(aq) + BY(aq) \longrightarrow BX(s) + AY(aq)$$

Cc 8.4

Cc 8.5 (a) The charge of a polyatomic ion is the charge associated with the ion *as a whole*. The oxidation states of the individual atoms must sum to the charge of the ion, but they are assigned to *the individual atoms themselves.*

Option (b) is incorrect because oxidation state and charge *are not identical,* even though the charge of a *monoatomic* ion is equal to its oxidation state.

Option (c) is incorrect because charge *is* a physical property of ions. Conversely, the oxidation states of atoms are *not* real physical properties, but an imposed electron bookkeeping scheme.

Cc 8.6 (d) Since oxidation and reduction must occur together, an increase in the oxidation state of a reactant is always accompanied by a decrease in the oxidation state of a reactant.

Cc 8.7 (a) Sodium is the most easily oxidized because it is highest on the activity series.