16 SOLUTIONS

Reviewing Content

42. The solvent is the substance in which the solute is dissolved.

43. Random collisions of the solvent molecules with the solute particles provide enough force to overcome gravity.

44. **solubility:** the amount of a substance that dissolves in a given quantity of solvent at specified conditions of temperature and pressure to produce a saturated solution.

saturated solution: a solution containing the maximum amount of solute for a given amount of solvent at a constant temperature and pressure. **unsaturated solution:** a solution that contains less solute than a saturated solution at a given temperature and pressure. **miscible:** describes liquids that dissolve in each other. **immiscible:** describes liquids that are insoluble in each other.

45. Particles of solute crystallize.

46. No; if there were undissolved solute, the excess solute would come out of a supersaturated solution.

47. 5.55×10^2 g $AgNO_3$

48. Solubility increases with pressure.

49. **a.** 1.6×10^{-2} g/L
b. 4.7×10^{-2} g/L

50. *Dilute* and *concentrated* are relative terms and are not quantitative. Molarity provides the exact number of moles of solute per liter of solution.

51. Molarity is the number of moles of solute dissolved in one liter of solution.
a. 1.3M KCl
b. 3.3×10^{-1}M $MgCl_2$

52. 2.00×10^1 mL

53. **a.** 5.0×10^{-1} mol NaCl, 29 g NaCl
b. 1.0 mol KNO_3, 1.0×10^{-2} g KNO_3
c. 2.5×10^2 mol $CaCl_2$, 2.8 g $CaCl_2$

54. **a.** 2.3×10^1 g NaCl
b. 2.0 g $MgCl_2$

55. **a.** 16% (v/v) ethanol
b. 63.6% (v/v) isopropyl alcohol

56. Colligative properties are properties of a solution that depend only on the number of solute particles; boiling-point elevation, freezing-point depression, and vapor-pressure lowering. Boiling points are elevated because shells of solvent form around solute particles, reducing the amount of solvent molecules that have sufficient energy to escape the solution; relative to the pure solvent, the amount of energy required to cause vaporization or boiling increases. Solutes disrupt the ordering of the solvent structure, so more kinetic energy must be withdrawn from a solution for it to solidify. This lowers the freezing point of the solution.

57. **a.** sea water
b. 1.5*M* KNO_3
c. 0.100*M* $MgCl_2$

58. The effective molality of the $Ca(NO_3)_2$ solution is 3m. The effective molality of the $NaNO_3$ solution is 2m.

59. When vapor pressure is lowered relative to pure solvent, more energy must be supplied to reach the boiling point; thus the boiling point is increased relative to pure solvent.

60. The salt lowers the freezing point of the ice-water cooling mixture.

61. 1*M* solution: 1 mol of solute in 1 L of solution; 1*m* solution: 1 mol of solute in 1000 g of solvent

62. Add 27.0 g H_2O to 32.0 g CH_3OH.

63. **a.** 100.26°C
b. 101.54°C

64. **a.** –4.46°C
b. –2.2°C

65. **a.** –1.1°C
b. –0.74°C
c. –1.5°C

Understanding Concepts

66. **a.** The freezing-point depression is twice as great for solute B; solute B must provide twice as many particles in solution.

b. Solute A probably forms a saturated solution.

67. $\Delta T_f = -9.60°C$; $\Delta T_b = +4.74°C$

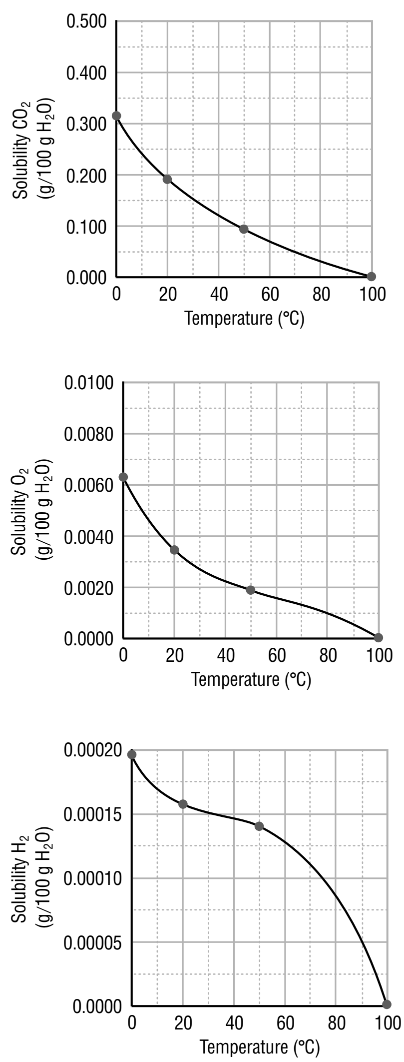
68. Each gram of acetone requires 0.93 g of water.

69. The mole fraction of $NaHCO_3$ is 0.020; of water is 0.98. The solution is 1.1*m*.

70. The mole fraction of NaCl is 2.69×10^{-3}; the mole fraction of H_2O is 9.97×10^{-1}.

71. Add one crystal of KNO_3. If the solution is supersaturated, crystallization occurs. If it is saturated, the crystal does not dissolve; if unsaturated, the crystal dissolves.

72.



73. **a.** about 1.14
b. about -7.2°C
c. about -9.5°C

74. fp = -1.86°C; bp = 100.512°C

75. $X_{C_2H_5OH} = 0.20$; $X_{H_2O} = 0.80$

76. –0.413°C

77. **a.** 44.2 g KCl
b. 5.8 g KCl

78. **a.** 0.30 mol
b. 0.40 mol
c. 0.50 mol
d. 0.20 mol

Critical Thinking

79. unsaturated

80. 100.680°C

81. **a.** 7.5 g H_2O_2
b. 8.8×10^{-1}M

82. 5.2×10^1 g $NaNO_3$

83. 8.55×10^1 g/mol

84. $X_{H_2O} = 0.972$; $X_{C_{12}H_{22}O_{11}} = 0.028$

85. $CaCl_2$ produces three particles upon dissolving; NaCl produces only two particles. Freezing-point depression depends on the number of solute particles in the solvent.

86. To solve this problem:
(1) For each ion, multiply molar mass by molality to find mass per 1000 g of solvent.
(2) Sum the masses from (1) and add to 1000 g.
(3) Calculate the percent mass of each ion by the mass of 5.00 L of sea water (5120 g).
chloride: 1.03×10^2 g
sodium: 5.68×10^1 g
magnesium: 7.1 g
sulfate: 1.4×10^1 g
calcium: 2.3 g
potassium: 2.0 g
hydrogen carbonate: 6×10^{-1} g

87. The solution with the higher concentration of ions will have the greater boiling point elevation; 6.00 g $Ca(NO_3)_2$ in 30 g of water.

Concept Challenge

88. 1.2×10^{-1}M HCl

89. 1.10×10^2 mL HNO_3

90. **a.** 76°C: 15 mol/kg; 33°C: 5 mol/kg
b. 82°C
c. 30° C

91. 9.0×10^{-2}M Na_2SO_4

92. Determine the freezing point of a suitable solvent. Dissolve a known mass of the unknown molecular compound in a known mass of the solvent. Determine the freezing point of the solution. This gives the freezing point depression. Use $\Delta T^{f} = K^{f} \times m$ to find the molality of the solution. Use the molality to find the moles of solute. Use the moles of solute and the measured mass of solute to calculate the molar mass.

$$\frac{\text{g solute}}{\cancel{\text{g solvent}}} \times \frac{\cancel{1000\text{ g solvent}}}{\cancel{1\text{ kg solvent}}} \times \frac{\cancel{1\text{ kg solvent}}}{1\text{ mol solute}} = \frac{\text{g solute}}{1\text{ mol solute}}$$

The molar mass obtained is valid only for an undissociating molecular solute.

Cumulative Review

93. **a.** 1.98×10^{2} g H_2O
b. 1.98×10^{5} mg H_2O
c. 1.98×10^{-1} kg H_2O

94. **a.** 3.47×10^{-1} kg
b. 7.3×10^{-5} kg
c. 9.43×10^{-6} kg
d. 8.77×10^{-4} kg

95. Rutherford's model contains a nucleus.

96. **a.** manganese, Mn
b. indium, In
c. francium, Fr
d. polonium, Po

97. Calcium permanganate is $Ca(MnO_4)_2$. Four formula units contain 4 Ca atoms, 8 Mn atoms, and 32 O atoms.

98. $C_8H_6O_4$

99. **a.** 5.58×10^{1} g Fe, 6.35×10^{1} g Cu, 2.01×10^{2} g Hg, 3.21×10^{1} g S
b. Each sample contains 6.02×10^{23} atoms.
c. 4.48×10^{-1} mol Fe, 3.93×10^{-1} mol Cu, 1.25×10^{-1} mol Hg, 7.80×10^{-1} mol S

100. 1.7×10^{4} L

101. **a.** combination
b. decomposition
c. single-replacement
d. combustion
e. single replacement
f. double-replacement

102. $2H^{+}(aq) + S^{2-}(aq) \rightarrow H_2S(g)$

103. **a.** $NH_4Cl(s) \rightarrow NH_4{+}(aq) + Cl^{-}(aq)$
b. $Cu(NO_3)_2(s) \rightarrow Cu^{2+}(aq) + 2NO_3^{-}(aq)$
c. $HNO_3(aq) \rightarrow H^{+}(aq) + NO_3^{-}(aq)$
d. $HC_2H_3O_2(l) \rightarrow H^{+}(aq) + C_2H_3O_2^{-}(aq)$
e. $Na_2SO_4(s) \rightarrow 2Na^{+}(aq) + SO_4^{2-}(aq)$
f. $HgCl_2(s) \rightarrow Hg^{2+}(aq) + 2Cl^{-}(aq)$

104. 4.9×10^{1} L

105. **a.** :Ï· (I with 7 valence electron dots) **b.** ·T̈e· (Te with 6 valence electron dots)
c. :S̈b: (Sb with 5 valence electron dots) **d.** ·Sr·

106. 1.08×10^{2} kPa

107. Ideal gas particles have neither volume nor inter-particle interactions.

108. Unbalanced intermolecular attractions between molecules at the surface of the liquid and those below the surface create an inward pull, or force, that minimizes the surface area to create surface tension.

109. The very polar hydrogen chloride produces hydronium ions (H_3O+) and chloride ions (Cl-) that are stabilized by solvent shells of water in aqueous solution. Hydrogen chloride does not dissociate in nonpolar benzene, and polar compounds generally have low solubility in nonpolar solvents.

110. a solution, if the soap mixture is very dilute; More concentrated mixtures of soap in water form colloids.