Solutions

Section 15.1 What are solutions?

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Practice Problems

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1. If 0.55 g of a gas dissolves in 1.0 L of water at 20.0 kPa of pressure, how much will dissolve at 110.0 kPa of pressure?

$$S_1 = \frac{0.55\ \text{g}}{1.0\ \text{L}} = 0.55\ \text{g/L}$$

$$S_2 = S_1 \times \frac{P_2}{P_1} = 0.55\ \text{g/L} \times \frac{110.0\ \cancel{\text{kPa}}}{20.0\ \cancel{\text{kPa}}} = 3.0\ \text{g/L}$$

2. A gas has a solubility of 0.66 g/L at 10.0 atm of pressure. What is the pressure on a 1.0-L sample that contains 1.5 g of gas?

$$S_2 = \frac{1.5\ \text{g}}{1.0\ \text{L}} = 1.5\ \text{g/L}$$

$$P_2 = P_1 \times \frac{S_2}{S_1} = 10.0\ \text{atm} \times \frac{1.5\ \cancel{\text{g/L}}}{0.66\ \cancel{\text{g/L}}} = 23\ \text{atm}$$

Section 15.1 Assessment

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3. Describe the characteristics of a solution and identify the various types.

All solutions are homogeneous mixtures containing two or more substances. Solutions may be liquid, solid, or gas. Solution types are identified in Table 15-1.

4. How do intermolecular forces affect solvation?

The attractive forces between solute and solvent particles overcome the forces holding the solute particles together, thus, pulling the solute particles apart.

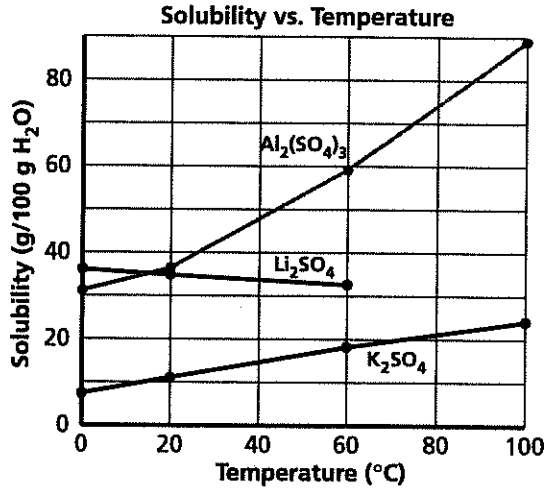
5. What is solubility? Describe two factors that affect solubility.

Solubility refers to the maximum amount of solute that can dissolve in a given amount of solvent at a particular temperature and pressure. Surface area, temperature, and pressure affect solubility.

6. Thinking Critically If a seed crystal was added to a supersaturated solution, how would you characterize the resulting solution?

After the excess solute particles crystallize out of solution, the solution is saturated.

7. **Making and Using Graphs** Use the information in **Table 15-2** to graph the solubilities of aluminum sulfate, lithium sulfate, and potassium sulfate at 0°C, 20°C, 60°C, and 100°C. Which substance's solubility is most affected by increasing temperature?



Aluminum sulfate shows the greatest change in solubility over the temperature range.

Section 15.2 Solution Concentration

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Practice Problems

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8. What is the percent by mass of $NaHCO_3$ in a solution containing 20 g $NaHCO_3$ dissolved in 600 mL H_2O?

$$600\ \text{mL}\ H_2O \times 1.0\ \text{g/mL} = 600\ \text{g}\ H_2O$$

$$\frac{20\ \text{g}\ NaHCO_3}{600\ \text{g}\ H_2O + 20\ \text{g}\ Na\ HCO_3} \times 100 = 3\%$$

9. You have 1500.0 g of a bleach solution. The percent by mass of the solute sodium hypochlorite, NaOCl, is 3.62%. How many grams of NaOCl are in the solution?

$$3.62\% = 100 \times \frac{\text{mass NaOCl}}{1500.0\ \text{g}}$$

$$\text{mass NaOCl} = 54.3\ \text{g}$$

10. In question 9, how many grams of solvent are in the solution?

$$1500.0\ \text{g} - 54.3\ \text{g} = 1445.7\ \text{g solvent}$$

11. What is the percent by volume of ethanol in a solution that contains 35 mL of ethanol dissolved in 115 mL of water?

$$\frac{35\ \text{mL}}{115\ \text{mL} + 35\ \text{mL}} \times 100 = 23\%$$

12. If you have 100.0 mL of a 30.0% aqueous solution of ethanol, what volumes of ethanol and water are in the solution?

$$30.0\% = 100 \times \frac{\text{volume ethanol}}{\text{volume solution}}$$

$$\text{volume ethanol} = 0.300 \times (\text{volume solution})$$
$$= 0.300 \times 100.0\ \text{mL}$$

$$\text{volume ethanol} = 30.0\ \text{mL}$$

$$\text{volume water} = 100.0\ \text{mL} - 30.0\ \text{mL} = 70.0\ \text{mL}$$

13. What is the percent by volume of isopropyl alcohol in a solution that contains 24 mL of isopropyl alcohol in 1.1 L of water?

$$\frac{24\ \text{mL}}{24\ \text{mL} + 1100\ \text{mL}} \times 100 = 2.1\%$$

14. What is the molarity of an aqueous solution containing 40.0 g of glucose ($C_6H_{12}O_6$) in 1.5 L of solution?

$$\text{mol } C_6H_{12}O_6 = 40.0\ \text{g} \times \frac{1\ \text{mol}}{180.16\ \text{g}} = 0.222\ \text{mol}$$

$$\text{molarity} = \frac{\text{mol } C_6H_{12}O_6}{1.5\ \text{L solution}} = \frac{0.222\ \text{mol}}{1.5\ \text{L}} = 0.148M$$

15. What is the molarity of a bleach solution containing 9.5 g of NaOCl per liter of bleach?

$$\text{mol NaOCl} = 9.5\ \text{g} \times \frac{1\ \text{mol}}{74.44\ \text{g}} = 0.128\ \text{mol}$$

$$\text{molarity} = \frac{\text{mol NaOCl}}{1.00\ \text{L solution}} = \frac{0.128\ \text{mol}}{1.00\ \text{L}}$$

$$= 0.128M$$

16. Calculate the molarity of 1.60 L of a solution containing 1.55 g of dissolved KBr.

$$\text{mol KBr} = 1.55\ \text{g} \times \frac{1\ \text{mol}}{119.0\ \text{g}} = 0.0130\ \text{mol KBr}$$

$$\text{molarity} = \frac{\text{mol KBr}}{1.60\ \text{L solution}} = \frac{0.0130\ \text{mol}}{01.60\ \text{L}}$$

$$= 8.13 \times 10^{-3}M$$

17. How many grams of $CaCl_2$ would be dissolved in 1.0 L of a 0.10*M* solution of $CaCl_2$?

$$\text{mol } CaCl_2 = (0.10M)(1.0\ \text{L}) = (0.10\ \text{mol/L})(1.0\ \text{L})$$
$$= 0.10\ \text{mol } CaCl_2$$

$$\text{mass } CaCl_2 = 0.10\ \text{mol } CaCl_2 \times \frac{110.98\ \text{g}}{1\ \text{mol}}$$
$$= 11\ \text{g } CaCl_2$$

18. A liter of 2*M* NaOH solution contains how many grams of NaOH?

$$\text{mol NaOH} = (2M)(1\ \text{L}) = (2\ \text{mol/L})(1\ \text{L}) = 2\ \text{mol}$$

$$\text{mass NaOH} = 2\ \text{mol NaOH} \times \frac{40.00\ \text{g}}{1\ \text{mol}}$$
$$= 80\ \text{g NaOH}$$

19. How many grams of $CaCl_2$ should be dissolved in 500.0 mL of water to make a 0.20*M* solution of $CaCl_2$?

$$\text{mol } CaCl_2 = 500.0\ \text{mL} \times \frac{1\ \text{L}}{1000\ \text{mL}} \times 0.20M$$

$$= 500.0\ \text{mL} \times \frac{1\ \text{L}}{1000\ \text{mL}} \times \frac{0.20\ \text{mol}}{1\ \text{L}}$$
$$= 0.10\ \text{mol}$$

$$\text{mass } CaCl_2 = 0.10\ \text{mol } CaCl_2 \times \frac{110.98\ \text{g}}{1\ \text{mol}}$$
$$= 11\ \text{g } CaCl_2$$

20. How many grams of NaOH are in 250 mL of a 3.0*M* NaOH solution?

$$\text{mol NaOH} = 250\ \text{mL} \times \frac{1\ \text{L}}{1000\ \text{mL}} \times 3.0M$$

$$= 250\ \text{mL} \times \frac{1\ \text{L}}{1000\ \text{mL}} \times \frac{3.0\ \text{mol}}{1\ \text{L}}$$

$$= 0.75\ \text{mol}$$

$$\text{mass NaOH} = 0.75\ \text{mol NaOH} \times \frac{40.00\ \text{g}}{1\ \text{mol}}$$

$$= 3.0 \times 10^1\ \text{g NaOH}$$

21. What volume of a 3.00*M* KI stock solution would you use to make 0.300 L of a 1.25*M* KI solution?

$$(3.00M)V_1 = (1.25M)(0.300\ \text{L})$$

$$V_1 = \frac{(1.25M)(0.300\ \text{L})}{3.00M} = 0.125\ \text{L} = 125\ \text{mL}$$

22. How many milliliters of a 5.0*M* H_2SO_4 stock solution would you need to prepare 100.0 mL of 0.25*M* H_2SO_4?

$$(5.0M)V_1 = (0.25M)(100.0\ \text{mL})$$

$$V_1 = \frac{(0.25M)(100.0\ \text{mL})}{5.0M} = 5.0\ \text{mL}$$

23. If you dilute 20.0 mL of a 3.5*M* solution to make 100.0 mL of solution, what is the molarity of the dilute solution?

$$(3.5M)(20.0\ \text{mL}) = M_2(100.0\ \text{mL})$$

$$M_2 = \frac{(3.5M)(20.0\ \text{mL})}{100.0\ \text{mL}} = 0.70M$$

24. What is the molality of a solution containing 10.0 g Na_2SO_4 dissolved in 1000.0 g of water?

$$\text{mol } Na_2SO_4 = 10.0\ \text{g } Na_2SO_4 \times \frac{1\ \text{mol}}{142.04\ \text{g}}$$

$$= 0.0704\ \text{mol } Na_2SO_4$$

$$\text{molality} = \frac{0.0704\ \text{mol } Na_2SO_4}{1.0000\ \text{kg } H_2O} = 0.0704m$$

25. What is the molality of a solution containing 30.0 g of naphthalene ($C_{10}H_8$) dissolved in 500.0 g of toluene?

$$\text{mol } C_{10}H_8 = 30.0\ \text{g } C_{10}H_8 \times \frac{1\ \text{mol}}{128.18\ \text{g}}$$

$$= 0.234\ \text{mol } C_{10}H_8$$

$$\text{molality} = \frac{0.234\ \text{mol } C_{10}H_8}{500.0\ \text{g toluene}} \times \frac{1000.0\ \text{g}}{1.0000\ \text{kg}}$$

$$= 0.468m$$

26. What is the mole fraction of NaOH in an aqueous solution that contains 22.8% NaOH by mass?

$$22.8\% = \frac{\text{mass NaOH}}{\text{mass NaOH} + \text{mass } H_2O} \times 100$$

Assume 100.0 g sample.

Then, mass NaOH = 22.8 g
mass H_2O = 100.0 g − (mass NaOH) = 77.2 g

$$\text{mol NaOH} = 22.8\ \text{g} \times \frac{1\ \text{mol}}{40.00\ \text{g}} = 0.570\ \text{mol NaOH}$$

$$\text{mol } H_2O = 77.2\ \text{g} \times \frac{1\ \text{mol}}{18.02\ \text{g}} = 4.28\ \text{mol } H_2O$$

$$\text{mol fraction NaOH} = \frac{\text{mol NaOH}}{\text{mol NaOH} + \text{mol } H_2O}$$

$$= \frac{0.570\ \text{mol NaOH}}{0.570\ \text{mol NaOH} + 4.28\ \text{mol } H_2O} = \frac{0.570}{4.85}$$

$$= 0.118$$

The mole fraction of NaOH is 0.118.

27. An aqueous solution of NaCl has a mole fraction of 0.21. What is the mass of NaCl dissolved in 100.0 mL of solution?

$$0.21 = \frac{\text{mol NaCl}}{\text{mol NaCl} + \text{mol } H_2O}$$

$$0.21(\text{mol NaCl}) + 0.21(\text{mol } H_2O) = \text{mol NaCl}$$

$$0.79(\text{mol NaCl}) = 0.21(\text{mol } H_2O)$$

$$\text{mol } H_2O = 100.0\ \text{mL} \times \frac{1.0\ \text{g}}{1\ \text{mL}} \times \frac{1\ \text{mol}}{18.02\ \text{g}}$$

$$= 5.55\ \text{mol } H_2O$$

$$\text{Therefore, mol NaCl} = \frac{0.21 \times 5.55\ \text{mol}}{0.79}$$

$$= 1.48\ \text{mol}$$

$$\text{mass NaCl} = 1.48\ \text{mol} \times 58.44\ \text{g/mol} = 86.5\ \text{g}$$

The mass of dissolved NaCl is 86.5 g.

Section 15.2 Assessment

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28. Distinguish between a dilute solution and a concentrated solution.

concentrated: large amount of solute relative to its solubility; dilute: small amount of solute relative to its solubility.

29. Compare and contrast five quantitative ways to describe the composition of solutions.

molarity, molality, and mole fraction are based on moles of solute per some other quantity; percent by volume and molarity are defined on a per volume of solution basis; molality and mole fraction are based on a per quantity of solvent basis; percent by mass and percent by volume are the only ratios involving percentages

30. Describe the laboratory procedure for preparing a specific volume of a dilute solution from a concentrated stock solution.

Calculate the volume of stock solution needed and add it to a volumetric flask. Add water up to the flask's calibration line.

31. Thinking Critically Explain the similarities and differences between a 1*M* solution of NaOH and a 1*m* solution of NaOH.

Both solutions contain NaOH (solute) dissolved in water (solvent). The 1*m* solution contains 1 mole of NaOH per kilogram of water; the 1*M* solution contains 1 mole of NaOH per liter of solution.

32. Using Numbers A can of chicken broth contains 450 mg of sodium chloride in 240.0 g of broth. What is the percent by mass of sodium chloride in the broth?

$$450 \text{ mg NaCl} \times \frac{1 \text{ g NaCl}}{10^3 \text{ g NaCl}} = 0.45 \text{ g NaCl}$$

$$\text{percent by mass} = \frac{0.45 \text{ g}}{240.0 \text{ g}} \times 100 = 0.19\%$$

Section 15.3 Colligative Properties of Solutions

pages 471–475

Practice Problems

page 475

33. What is the boiling point and freezing point of a 0.625*m* aqueous solution of any nonvolatile, nonelectrolyte solute?

$\Delta T_b = 0.512°C/\cancel{m} \times 0.625\cancel{m} = 0.320°C$

$T_b = 100°C + 0.320°C = 100.320°C$

$\Delta T_f = 1.86°C/\cancel{m} \times 0.625\cancel{m} = 1.16°C$

$T_f = 0.0°C - 1.16°C = -1.16°C$

34. What is the boiling point and freezing point of a 0.40*m* solution of sucrose in ethanol?

$\Delta T_b = 1.22°C/\cancel{m} \times 0.40\cancel{m} = 0.49°C$

$T_b = 78.5°C + 0.49°C = 79.0°C$

$\Delta T_f = 1.99°C/\cancel{m} \times 0.40\cancel{m} = 0.80°C$

$T_f = -114.1°C - 0.80°C = -114.9°C$

35. A lab technician determines the boiling point elevation of an aqueous solution of a nonvolatile, nonelectrolyte to be 1.12°C. What is the solution's molality?

$1.12°C = 0.512°C/m \times m$

$m = 2.19m$

36. A student dissolves 0.500 mol of a nonvolatile, nonelectrolyte solute in one kilogram of benzene (C_6H_6). What is the boiling point elevation of the resulting solution?

$0.500 \text{ mol}/1.00 \text{ kg} = 0.500m$

$\Delta T_b = 2.53°C/m \times 0.500m = 1.26°C$

Section 15.3 Assessment

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37. Explain the nature of colligative properties.

Colligative properties depend on the number of solute particles in a solution.

CHEMLAB

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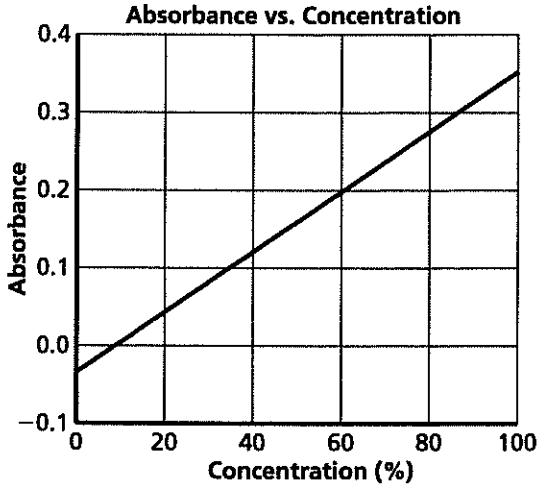
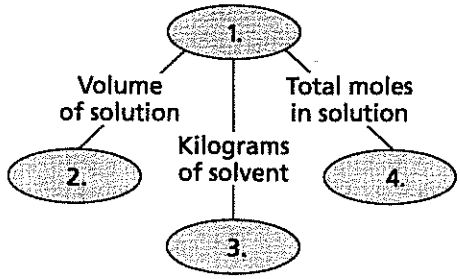
Analyze and Conclude



Chapter 15 Assessment *pages 484–486*

Concept Mapping

47. Complete the following concept map using the following terms: molarity, mole fraction, molality, moles of solute.



1. moles of solute; 2. molarity; 3. molality; 4. mole fraction

Mastering Concepts

48. What is the difference between solute and solvent? (15.1)

A solute is the substance being dissolved. The solvent is the substance in which the solute dissolves.

49. What determines whether a solute will be soluble in a given solvent? (15.1)

the polarity of the solute and solvent, temperature, and pressure

50. Explain the difference between saturated and unsaturated solutions. (15.1)

A saturated solution contains the maximum amount of solute under a given set of conditions. An unsaturated solution contains less than the maximum amount.

51. What does it mean if two liquids are said to be miscible? (15.1)

Two liquids are miscible when they are soluble in each other in any proportion.

52. What are three ways to increase the rate of solvation? (15.1)

increase the temperature of the solvent, increase the surface area of the solute, agitation

53. Why are gases less soluble at higher temperatures? (15.1)

An increase in temperature increases the kinetic energy of the gas particles. More gas particles escape the surface of the solution.

54. What is the difference between percent by mass and percent by volume? (15.2)

Percent by mass is a comparison between the mass of solute and the total mass of the solute. Percent by volume is a comparison between the volume of the solute and the total volume of the solution.

38. Describe four colligative properties of solutions.

vapor pressure lowering: the decrease in vapor pressure with increasing solute particles in solution; boiling point elevation: the increase in boiling point with increasing solute particles in solution; freezing point depression: the decrease in freezing point with increasing solute particles in solution; osmotic pressure: the change in osmotic pressure with increasing solute particles in solution

39. Explain why a solution has a lower boiling point than the pure solvent.

Solute particles in solution decrease the vapor pressure above the solution. Because a solution boils when its vapor pressure equals the external pressure, this decrease in vapor results in the need for a higher temperature in order for the solution to boil.

40. Thinking Critically Explain why the colligative properties described in this section may not apply to solutions containing volatile solutes. Hint: Volatile solutes are able to leave the liquid phase and enter the gas phase.

Volatile solute particles leave the solution. Thus, they are no longer a factor in affecting colligative properties.

41. Using Numbers Calculate the boiling point elevation and freezing point depression of a solution containing 50.0 g of glucose ($C_6H_{12}O_6$) dissolved in 500.0 g of water.

$$50.0\,\text{g glucose} \times \frac{1\text{ mol}}{180.15\,\text{g}} = 0.278\text{ mol glucose}$$

$$\text{molality} = \frac{0.278\text{ mol glucose}}{0.5000\text{ kg } H_2O} = 0.556m$$

$$\Delta T_b = (0.512°C/m)(0.556m) = 0.285°C$$

$$T_b = 100.000°C + 0.285°C = 100.285°C$$

$$\Delta T_f = (1.86°C/m)(0.556m) = 1.03°C$$

$$T_f = 0.00°C - 1.03°C = -1.03°C$$

Section 15.4 Heterogeneous Mixtures

pages 476–479

Section 15.4 Assessment

page 479

42. Distinguish between suspensions and colloids.

Suspension particles are larger than colloidal particles. Suspension particles settle out of the mixture, whereas colloidal particles do not.

43. Describe different types of colloids.

Student answers may vary. See Table 15-6 for descriptions of colloid types.

44. Why do dispersed colloid particles stay dispersed?

The particles do not settle out because they have polar or charged layers surrounding them. These layers repel each other and prevent the particles from settling or separating.

45. Thinking Critically Use the Tyndall effect to explain why it is more difficult to drive through fog using high beams than using low beams.

High beams are aimed farther down the road than low beams. Because the fog scatters light, there is less light from the high beams to illuminate the road than from the low beams. Also, because the high beams are aimed more directly into the fog, more of their light is reflected back toward the driver, making it more difficult to see.

46. Comparing and Contrasting Make a table that compares the properties of solutions, suspensions, and colloids.

Student tables will vary, but should include particle size, if the particles settle out, and if the particles display the Tyndall effect.

55. What is the difference between molarity and molality? (15.2)

Molarity is solution concentration expressed as the moles of solute per volume of solution. Molality expresses concentration as moles of solute per kilogram of solvent. Molality does not depend upon the temperature of the solution.

56. Explain on a particle basis why the vapor pressure of a solution is lower than a pure solvent. (15.3)

When a solvent contains a solute, fewer solvent particles occupy the surface. Fewer particles escape into the gaseous state.

57. How does a solute affect the boiling point of a solution? (15.3)

A liquid boils when its vapor pressure equals atmospheric pressure. The vapor pressure of a solution is less than pure solvent. Thus, the boiling point is higher.

58. How does a solute affect the freezing point of a solution? (15.3)

A solute interferes with the attractive forces between solvent particles. The freezing point is lowered.

59. Describe osmosis. (15.4)

Osmosis is the diffusion of solvent particles across a semipermeable membrane.

60. What is a colligative property? (15.4)

A colligative property is a property of a solution that depends on concentration and not the identity of the solute.

61. What is a suspension and how does it differ from a colloid? (15.4)

A suspension is a heterogeneous mixture that settles out if left undisturbed. The particles dispersed in a colloid are much smaller than those in a suspension and do not settle out.

62. Name a colloid formed from a gas dispersed in a liquid. (15.4)

Student answers may include whipped cream or beaten egg whites.

63. How can the Tyndall effect be used to distinguish between a colloid and a solution? Why? (15.4)

A beam of light is visible in a colloid but not in a solution. Dispersed colloid particles are large enough to scatter light (Tyndall effect).

Mastering Problems

Henry's Law (15.1)

Level 1

64. The solubility of a gas in water is 0.22 g/L at 20.0 kPa of pressure. What is the solubility when the pressure is increased to 115 kPa?

$$S = \frac{(0.22\ \text{g/L})(115\ \cancel{\text{kPa}})}{20.0\ \cancel{\text{kPa}}} = 1.3\ \text{g/L}$$

65. The solubility of a gas in water is 0.66 g/L at 15 kPa of pressure. What is the solubility when the pressure is increased to 40.0 kPa?

$$S = \frac{(0.66\ \text{g/L})(40.0\ \cancel{\text{kPa}})}{15\ \cancel{\text{kPa}}} = 1.8\ \text{g/L}$$

Level 2

66. The solubility of a gas is 2.0 g/L at 50.0 kPa of pressure. How much gas will dissolve in 1 L at a pressure of 10.0 kPa?

$$1.0\ \cancel{\text{L}} \times \frac{(2.0\ \text{g}/\cancel{\text{L}})(10.0\ \cancel{\text{kPa}})}{50.0\ \cancel{\text{kPa}}} = 0.40\ \text{g}$$

67. The solubility of a gas is 4.5 g/L at a pressure of 1.0 atm. At what pressure will there be 45 g of gas in 1.0 L of solution?

$$P = \frac{(45\ \text{g}/\cancel{\text{L}})(1.0\ \text{atm})}{4.5\ \text{g}/\cancel{\text{L}}} = 1.0 \times 10^1\ \text{atm}$$

68. The partial pressure of CO_2 inside a bottle of soft drink is 4.0 atm at 25°C. The solubility of CO_2 is 0.12 mol/L. When the bottle is opened, the partial pressure drops to 3.0×10^{-4} atm. What is the solubility of CO_2 in the open drink? Express your answer in grams per liter.

$$S = \frac{(0.12 \text{ mol/L})(3.0 \times 10^{-4} \cancel{\text{atm}})}{4.0 \cancel{\text{atm}}}$$

$$= 9.0 \times 10^{-6} \text{ mol/L } CO_2$$

$$\frac{9.0 \times 10^{-6} \cancel{\text{mol } CO_2}}{1 \text{ L}} \times \frac{44.01 \text{ g } CO_2}{1 \cancel{\text{mol } CO_2}}$$

$$= 4.0 \times 10^{-4} \text{ g/L } CO_2$$

Percent Solutions (15.2)

Level 1

69. Calculate the percent by mass of 3.55 g NaCl dissolved in 88 g water.

$$\text{percent by mass} = \frac{3.55 \text{ g NaCl}}{3.55 \text{ g NaCl} + 88 \text{ g NaCl}} \times 100 = 3.9\%$$

70. Calculate the percent by mass of benzene in a solution containing 14.2 g of benzene in 28.0 g of carbon tetrachloride.

$$\text{percent by mass} = \frac{14.2 \text{ g benzene}}{14.2 \text{ g benzene} + 28.0 \text{ g } CCl_4} \times 100 = 33.6\%$$

71. What is the percent by volume of 25 mL of methanol in 75 mL of water?

$$\text{percent by volume} = \frac{25 \text{ mL methanol}}{25 \text{ mL methanol} + 75 \text{ mL } H_2O} \times 100 = 25\%$$

Level 2

72. A solution is made by adding 1.23 mol KCl to 1000.0 g of water. What is the percent by mass of KCl in this solution?

$$\text{mass of KCl} = 1.23 \cancel{\text{mol KCl}} \times \frac{74.55 \text{ g KCl}}{1 \cancel{\text{mol KCl}}}$$

$$= 91.7 \text{ g KCl}$$

$$\text{percent by mass} = \frac{91.7 \text{ g KCl}}{91.7 \text{ g KCl} + 1000.0 \text{ g } H_2O} \times 100 = 8.40\%$$

73. What mass of water must be added to 255.0 g NaCl to make a 15.00 percent by mass aqueous solution?

Let x = the mass of water

$$15.00\% = \frac{255.0 \text{ g NaCl}}{255.0 \text{ g NaCl} + x} \times 100$$

$$0.1500 = \frac{255.0 \text{ g}}{255.0 \text{ g} + x}$$

$$255.0 \text{ g} + x = \frac{255.0 \text{ g}}{0.1500}$$

$$x = \frac{255.0 \text{ g}}{0.1500} - 255.0 \text{ g} = 1445 \text{ g } H_2O$$

74. The label on a 250-mL stock bottle reads "21.5% alcohol by volume." What volume of alcohol does it contain?

$$250 \cancel{\text{mL solution}} \times \frac{21.5 \text{ mL alcohol}}{100 \cancel{\text{mL solution}}}$$

$$= 54 \text{ mL alcohol}$$

75. A 14.0 percent by mass solution of potassium iodide dissolved in water has a density of 1.208 g/mL. How many grams of KI are in 25.0 mL of the solution?

$$25.0 \cancel{\text{mL solution}} \times \frac{1.208 \text{ g solution}}{1 \cancel{\text{mL solution}}}$$

$$= 30.2 \text{ g solution}$$

$$\text{mass of KI} = 30.2 \cancel{\text{g solution}} \times \frac{14.0 \text{ g KI}}{100.0 \cancel{\text{g solution}}}$$

$$= 4.23 \text{ g KI g}$$

Molarity (15.2)

Level 1

76. What is the molarity of the following solutions?

a. 2.5 mol KCl in 1.0 L of solution

$$\frac{2.5 \text{ mol KCl}}{1.0 \text{ L}} = 2.5M \text{ KCl}$$

b. 1.35 mol H_2SO_4 in 245 mL of solution

$$\frac{1.35 \text{ mol } H_2SO_4}{245 \cancel{\text{mL}}} \times \frac{1000 \cancel{\text{mL}}}{1 \text{ L}}$$

$$= 5.51M \text{ } H_2SO_4$$

c. 0.875 mol of ammonia in 155 mL of solution

$$\frac{0.875 \text{ mol } NH_3}{155 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 5.65M \text{ } NH_3$$

Level 2

77. What is the molarity of the following solutions?

a. 0.96 g $MgCl_2$ in 500 mL of solution

$$\frac{0.96 \text{ g } MgCl_2}{500 \text{ mL}} \times \frac{1 \text{ mol } MgCl_2}{95.21 \text{ g } MgCl_2} \times \frac{1000 \text{ mL}}{1 \text{ L}}$$

$$= 0.02M \text{ } MgCl_2$$

b. 9.33 g Na_2S in 450 mL solution

$$\frac{9.33 \text{ g } Na_2S}{450 \text{ mL}} \times \frac{1 \text{ mol } Na_2S}{77.99 \text{ g } Na_2S} \times \frac{1000 \text{ mL}}{1 \text{ L}}$$

$$= 0.27M \text{ } Na_2S$$

c. 2.48 g CaF_2 in 375 mL of solution

$$\frac{2.48 \text{ g } CaF_2}{375 \text{ mL}} \times \frac{1 \text{ mol } CaF_2}{78.08 \text{ g } CaF_2} \times \frac{1000 \text{ mL}}{1 \text{ L}}$$

$$= 0.0847M \text{ } CaF_2$$

78. How many moles of solute are contained in the following solutions?

a. 15.25 mL 2.10*M* $CaCl_2$

$$15.25 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{2.10 \text{ mol } CaCl_2}{1 \text{ L}}$$

$$= 0.0320 \text{ mol } CaCl_2$$

b. 125 mL 0.0500*M* $Ba(OH)_2$

$$125 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.0500 \text{ mol } Ba(OH)_2}{1 \text{ L}}$$

$$= 0.00625 \text{ mol } Ba(OH)_2$$

c. 53.1 mL 12.2*M* HCl

$$53.1 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{12.2 \text{ mol HCl}}{1 \text{ L}}$$

$$= 0.648 \text{ mol HCl}$$

79. How many grams of solute are contained in the following solutions?

a. 64.3 mL 0.0238*M* KOH

$$64.3 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \frac{0.0238 \text{ mol KOH}}{1 \text{ L}} \times$$

$$\frac{56.10 \text{ g KOH}}{1 \text{ mol KOH}} = 0.0859 \text{ g KOH}$$

b. 142 mL 1.40*M* K_2SO_4

$$142 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1.40 \text{ mol } K_2SO_4}{1 \text{ L}} \times$$

$$\frac{174.27 \text{ g } K_2SO_4}{1 \text{ mol } K_2SO_4} = 34.6 \text{ g } K_2SO_4$$

c. 750.0 mL 0.225*M* NH_4OH

$$750.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.225 \text{ mol } NH_4OH}{1 \text{ L}} \times$$

$$\frac{35.05 \text{ g } NH_4OH}{1 \text{ mol } NH_4OH} = 5.91 \text{ g } NH_4OH$$

Molar Dilution (15.2)

Level 1

80. How many milliliters of 2.55*M* NaOH is needed to make 125 mL 0.75*M* NaOH solution?

$$M_1V_1 = M_2V_2$$

$$V_2 = \frac{(125 \text{ mL})(0.75M)}{(2.55M)} = 37 \text{ mL}$$

81. How many milliliters of 0.400*M* HBr solution can be made from 50.0 mL of 8.00*M* HBr solution?

$$M_1V_1 = M_2V_2$$

$$V_2 = \frac{(50.0 \text{ mL})(8.00M)}{(0.400M)} = 1.00 \times 10^3 \text{ mL}$$

Level 2

82. What is the molarity of each resulting solution when the following mixtures are prepared?

a. 500.0 mL H_2O is added to 20.0 mL 6.00*M* HNO_3

$$\frac{(20.0\text{ mL})(6.00M\ HNO_3)}{500.0\text{ mL} + 20.0\text{ mL}} = 0.240M\ HNO_3$$

b. 30.0 mL 1.75*M* HCl is added to 80.0 mL 0.450*M* HCl

$$\frac{(30.0\text{ mL})(1.75M) + (80.0\text{ mL})(0.450M)}{30.0\text{ mL} + 80.0\text{ mL}}$$

$$= 0.805M\ HCl$$

Molality and Mole Fraction (15.2)

Level 1

83. Calculate the molality of the following solutions.

a. 15.7 g NaCl in 100.0 g H_2O

$$\frac{15.7\text{ g NaCl}}{100.0\text{ g } H_2O} \times \frac{1000\text{ g } H_2O}{1\text{ kg } H_2O} \times \frac{1\text{ mol NaCl}}{58.44\text{ g NaCl}}$$

$$= 2.69m\ NaCl$$

b. 20.0 g $CaCl_2$ in 700.0 g H_2O

$$\frac{20.0\text{ g } CaCl_2}{700.0\text{ g } H_2O} \times \frac{1000\text{ g } H_2O}{1\text{ kg } H_2O} \times$$

$$\frac{1\text{ mol } CaCl_2}{110.97\text{ g } CaCl_2} = 0.257m\ CaCl_2$$

c. 3.76 g NaOH in 0.850 L H_2O

$$\frac{3.76\text{ g NaOH}}{0.850\text{ L } H_2O} \times \frac{1\text{ L}}{1\text{ kg}} \times \frac{1\text{ mol NaOH}}{40.00\text{ g NaOH}}$$

$$= 0.111m$$

84. Calculate the mole fraction of NaCl, $CaCl_2$, and NaOH in the solutions listed in the previous problem.

a. $15.7\text{ g NaCl} \times \frac{1\text{ mol NaCl}}{58.44\text{ g NaCl}} = 0.269\text{ mol NaCl}$

$$100.0\text{ g } H_2O \times \frac{1\text{ mol } H_2O}{18.02\text{ g } H_2O} = 5.549\text{ mol } H_2O$$

$$\text{mole fraction} = \frac{0.269\text{ mol}}{0.269\text{ mol} + 5.549\text{ mol}}$$

$$= 0.0462$$

b. $20.0\text{ g } CaCl_2 \times \frac{1\text{ mol } CaCl_2}{110.97\text{ g } CaCl_2}$

$$= 0.180\text{ mol } CaCl_2$$

$$700.0\text{ g } H_2O \times \frac{1\text{ mol } H_2O}{18.01\text{ g } H_2O} = 38.84\text{ mol } H_2O$$

$$\text{mole fraction} = \frac{0.180\text{ mol}}{0.180\text{ mol} + 38.84\text{ mol}}$$

$$= 0.00461$$

c. $3.76\text{ g NaOH} \times \frac{1\text{ mol NaOH}}{40.00\text{ g NaOH}}$

$$= 0.0940\text{ mol NaOH}$$

$$0.850\text{ L } H_2O \times \frac{1000\text{ g } H_2O}{1\text{ L } H_2O} \times \frac{1\text{ mol } H_2O}{18.02\text{ g } H_2O}$$

$$= 47.2\text{ mol } H_2O$$

$$\text{mole fraction} = \frac{0.0940\text{ mol}}{0.0940\text{ mol} + 47.2\text{ mol}}$$

$$= 0.00199$$

Level 2

85. What are the molality and mole fraction of solute in a 35.5 percent by mass aqueous solution of formic acid (HCOOH)?

$$35.5\%\text{ means } \frac{35.5\text{ g HCOOH}}{100.0\text{ g solution}}$$

$$35.5\text{ g } CH_3OH \times \frac{1\text{ mol HCOOH}}{46.03\text{ g HCOOH}}$$

$$= 0.771\text{ mol HCOOH}$$

$$\text{mass of water} = 100.0\text{ g} - 35.5\text{ g} = 64.5\text{ g}$$
$$= 6.45 \times 10^{-2}\text{ kg}$$

$$\text{moles of water} = 64.5\text{ g} \times \frac{1\text{ mol } H_2O}{18.02\text{ g } H_2O}$$

$$= 3.58\text{ mol } H_2O$$

$$\text{molality} = \frac{0.771\text{ mol HCOOH}}{6.45 \times 10^{-2}\text{ kg } H_2O} = 12.0m$$

$$\text{mole fraction} = \frac{0.771\text{ mol}}{0.771\text{ mol} + 3.58\text{ mol}} = 0.177$$

Colligative Properties (15.3)

Level 1

86. Using the information in **Tables 15-4** and **15-5**, calculate the freezing point and boiling point of 12.0 g of glucose ($C_6H_{12}O_6$) in 50.0 g H_2O.

molar mass of glucose = 180.10 g/mol

moles of glucose = 12.0 ~~g glucose~~ $\times \frac{1 \text{ mol glucose}}{180.15 \text{ g glucose}} = 0.0666 \text{ mol glucose}$

mass of solvent = 50.0 g $H_2O \times \frac{1 \text{ kg } H_2O}{1000 \text{ g } H_2O}$
$= 5.00 \times 10^{-2}$ kg H_2O

molality $= \frac{0.0666 \text{ mol glucose}}{5.00 \times 10^{-2} \text{ kg } H_2O} = 1.33m$

$\Delta T_f = (1.86°C/m)(1.33m) = 2.57°C$
freezing point = 0.0°C − 2.47°C = −2.47°C

$\Delta T_b = (0.512°C/m)(1.33m) = 0.681°C$
boiling point = 100.0°C + 0.681°C = 100.681°C

Level 2

87. Using the information in **Tables 15-4** and **15-5**, calculate the freezing point and boiling point of each of the following solutions.

a. 2.75*m* NaOH in water

$\Delta T_f = (1.86°C/m)(2.75m)(2) = 10.2°C$
freezing point = 0.0°C − 10.2°C = −10.2°C

$\Delta T_b = (0.512°C/m)(2.75m)(2) = 2.82°C$
boiling point = 100.0°C + 2.82°C = 102.82°C
= 102.8°C

b. 0.586*m* of water in ethanol

$\Delta T_f = (1.99°C/m)(0.586m) = 1.17°C$
freezing point = −114.6°C − 1.17°C
= −115.77°C = −115.8°C

$\Delta T_b = (1.22°C/m)(0.586m) = 0.715°C$
boiling point = 78.4°C + 0.715°C = 79.115°C
= 79.1°C

c. 1.26*m* of naphthalene ($C_{10}H_8$) in benzene

$\Delta T_f = (5.12°C/m)(1.26m) = 6.45°C$
freezing point = 5.5°C − 6.45°C = −0.95°C
= −1.0°C

$\Delta T_b = (2.53°C/m)(1.26m) = 3.19°C$
boiling point = 80.1°C + 3.19°C = 83.29°C
= 83.3°C

88. A rock salt (NaCl), ice, and water mixture is used to cool milk and cream to make homemade ice cream. How many grams of rock salt must be added to water to lower the freezing point 10.0°C?

$\Delta T_f = K_f m$

$m = \frac{\Delta T_f}{K_f} = \frac{10.0°C}{1.86°C/m} = 5.38m$ ions of Na^+ and Cl^-

molality $= \frac{\text{moles of solute}}{\text{kilograms of solvent}}$

$= \frac{2.69 \text{ mol NaCl}}{1 \text{ kg solvent}}$

$\frac{2.69 \text{ ~~mol NaCl~~}}{1 \text{ kg } H_2O} \times \frac{58.44 \text{ g NaCl}}{1 \text{ ~~mol NaCl~~}}$

= 157 g NaCl per 1 kg H_2O

89. Calculate the freezing point and boiling point of a solution that contains 55.4 g NaCl and 42.3 g KBr dissolved in 750.3 mL H_2O.

moles of NaCl = 55.4 ~~g NaCl~~ $\times \frac{1 \text{ mol NaCl}}{58.44 \text{ ~~g NaCl~~}}$
= 0.948 mol NaCl

moles of KBr = 42.3 ~~g KBr~~ $\times \frac{1 \text{ mol KBr}}{119.00 \text{ ~~g KBr~~}}$
= 0.355 mol KBr

total moles of solute = 0.948 mol + 0.355 mol
= 1.303 mol

mass of water = 750.3 ~~mL~~ $\times \frac{1 \text{ ~~g~~}}{1 \text{ ~~mL~~}} \times \frac{1 \text{ kg}}{1000 \text{ ~~g~~}}$
= 0.7053 kg

molality $= \frac{1.303 \text{ mol}}{0.7503 \text{ kg}} = 1.737m$

$\Delta T_f = (1.86°C/m)(1.737m)(2) = 6.46°C$
freezing point = 0.00°C − 6.46°C = −6.46°C

$\Delta T_b = (0.521°C/m)(1.737m)(2) = 1.78°C$
boiling point = 100.00°C + 1.78°C = 101.81°C

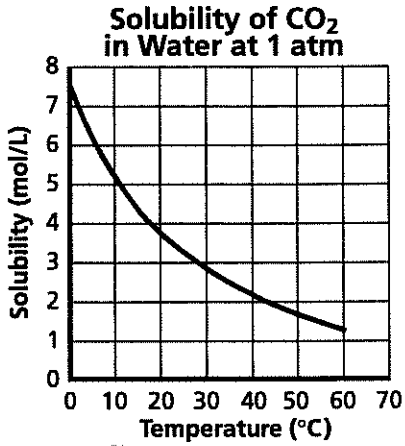
Mixed Review

Sharpen your problem-solving skills by answering the following.

90. If you prepared a saturated aqueous solution of potassium chloride at 25°C and then heated it to 50°C, would you describe the solution as unsaturated, saturated, or supersaturated? Explain.

unsaturated; the solubility of KCl in water increases with temperature. A solution at 50°C holds more solute than one at 25°C.

91. Use the graph below to explain why a carbonated beverage does not go flat as quickly when it contains ice.



Ice keeps the drink at a temperature at which the carbon dioxide has greater solubility.

92. Which of the following substances will be soluble in the nonpolar solvent carbon tetrachloride (CCl_4): Br_2, C_6H_{14}, $NaNO_3$, HCl? Explain.

Br_2, C_6H_{14}; They are nonpolar molecules. Like dissolves like; therefore, they are soluble in nonpolar solvents.

93. How many grams of calcium nitrate ($Ca(NO_3)_2$) would you need to prepare 3.00 L of a 0.500*M* solution?

$$3.00\,\text{L} \times \frac{0.500\ \text{mol Ca(NO}_3)_2}{1\,\text{L}} \times \frac{164.09\ \text{g}}{1\ \text{mol Ca(NO}_3)_2}$$

$$= 246\ \text{g Ca(NO}_3)_2$$

94. What would be the molality of the solution described in the previous problem?

$$\text{mass of solvent} = 3.00\,\text{L} \times \frac{1\ \text{kg}}{1\,\text{L}} = 3.00\ \text{kg}$$

$$\text{moles of Ca(NO}_3)_2 = 3.00\,\text{L} \times \frac{0.500\ \text{mol Ca(NO}_3)_2}{1\,\text{L}}$$

$$= 1.50\ \text{mol Ca(NO}_3)_2$$

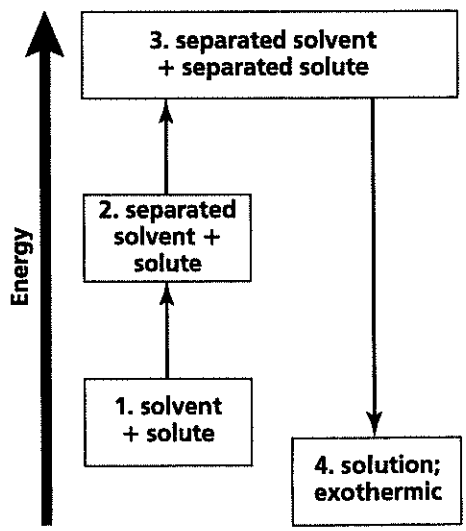
$$\text{molality} = \frac{1.50\ \text{mol Ca(NO}_3)_2}{3.00\ \text{kg H}_2\text{O}} = 0.500m$$

Thinking Critically

95. Inferring Why not spread a nonelectrolyte on a road to help ice melt?

An electrolyte will dissociate and produce a greater freezing point depression.

96. Using Scientific Diagrams Complete the diagram below using the following phrases: solution, separated solvent + solute, separated solvent + separated solute, solvent + solute. Is the process described exothermic or endothermic?



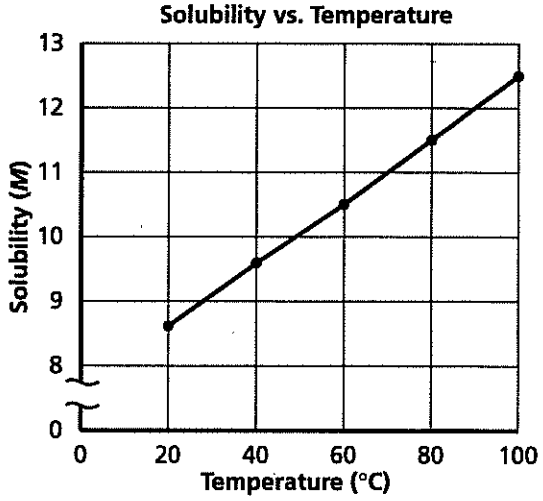
97. Designing an Experiment You are given a sample of a solid solute and three aqueous solutions containing that solute. How would you determine which solution is saturated, unsaturated, and supersaturated?

Add a pinch of solute to each container. If the solution is supersaturated, crystallization will occur; saturated, no solute will dissolve; unsaturated, solute will dissolve.

98.  **Using Graphs** The following solubility data was collected in an experiment. Plot a graph of the molarity of KI versus temperature. What is the solubility of KI at 55°C?

Table 15-7

Solubility of KI Data	
Temperature (°C)	**Grams of KI per 100.0 g solution**
20	144
40	162
60	176
80	192
100	206



Molarity equals 8.67*M*, 9.76*M*, 10.6*M*, 11.6*M*, and 12.4M at 20°C, 40°C, 60°C, 80°C, and 100°C, respectively. The solubility of KI at 55°C is about 10.4*M*.

99. Comparing Which of the following solutions has the highest concentration? Rank the solutions from the greatest to the smallest boiling point depression. Explain your answer.

a. 0.10 mol NaBr in 100.0 mL solution

b. 2.1 mol KOH in 1.00 L solution

c. 1.2 mol $KMnO_4$ in 3.00 L solution

The molarities are 1.0*M* NaBr, 2.1*M* KOH, and 0.40*M* $KMnO_4$. Because the KOH solution has the greatest concentration, it has the greatest boiling point elevation; $KMnO_4$ has the lowest concentration and the smallest boiling point depression. Boiling point elevation depends only upon concentration.

Writing in Chemistry

100. Investigate the total amount of salt used in the U.S. Construct a circle graph showing the different uses and amounts. Discuss each of these areas in detail. Salt was once used as a currency of high value. Find out why this was the case.

Student answers will vary.

101. Look up the various electrolytes in the human blood stream and discuss the importance of each.

Electrolyte cations should include sodium, potassium, magnesium, and calcium; anions should include chloride, sulfate, phosphate, and bicarbonate

102. Research the contents of the tank scuba divers typically use. How does its composition differ from the air that you breathe? What is the condition known as the bends? How is it treated?

Answers should include the following: Scuba tanks contain a mixture of primarily oxygen, nitrogen, and helium. If the diver ascends too quickly, dissolved N_2 bubbles come out of solution and cause blockage of capillaries and damage to the nervous system. The bends is treated in a hyperbaric chamber in which pressure is slowly decreased.

Cumulative Review

Refresh your understanding of previous chapters by answering the following.

103. The radius of an argon atom is 94 pm. Assuming the atom is spherical, what is the volume of an argon atom in nm^3? $V = 4/3\pi r^3$ (Chapter 2)

$$94 \text{ pm} \times \frac{1 \text{ nm}}{1000 \text{ pm}} = 0.094 \text{ nm}$$

$$V = 4/3(3.14)(0.094 \text{ nm})^3 = 3.5 \times 10^{-3} \text{ nm}^3$$

104. Identify which of the following molecules is polar. (Chapter 9)

a. SiH_4

nonpolar

b. NO_2

polar

c. H_2S

polar

d. NCl_3

polar

105. Name the following compounds. (Chapter 8)

a. NaBr

sodium bromide

b. $Pb(CH_3COO)_2$

lead acetate

c. $(NH_4)_2CO_3$

ammonium carbonate

106. A 12.0-g sample of an element contains 5.94×10^{22} atoms. What is the unknown element? (Chapter 11)

$$5.94 \times 10^{22} \text{ atoms} \times \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ atoms}}$$

$$= 0.0987 \text{ mol}$$

$$\frac{12.0 \text{ g}}{0.0987 \text{ mol}} = 122 \text{ g/mol}$$

The atomic mass is 122 amu. The element is antimony.

107. Pure bismuth can be produced by the reaction of bismuth oxide with carbon at high temperatures.

$$2Bi_2O_3 + 3C \rightarrow 4Bi + 3CO_2$$

How many moles of Bi_2O_3 reacted to produce 12.6 moles of CO_2? (Chapter 12)

$$12.6 \text{ mol } CO_2 \times \frac{2 \text{ mol } Bi_2O_3}{3 \text{ mol } CO_2} = 8.40 \text{ mol } Bi_2O_3$$

108. A gaseous sample occupies 32.4 mL at −23°C and 0.75 atm. What volume will it occupy at STP? (Chapter 14)

$T_1 = 273 - 23 = 250$ K

$T_2 = 273$ K

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$V_2 = \frac{(0.75 \text{ atm})(32.4 \text{ mL})(273 \text{ K})}{(250 \text{ K})(1.0 \text{ atm})} = 26 \text{ mL}$$

Standardized Test Practice Chapter 15

page 487

1. How much water must be added to 6.0 mL of a 0.050*M* stock solution to dilute it to 0.020*M*?

a. 15 mL
b. 9.0 mL
c. 6.0 mL
d. 2.4 mL

$M_1V_1 = M_2V_2$

$V_2 = M_1V_1/M_2 = (0.050M)(6.0 \text{ mL})/(0.020M)$
$= 15$ mL

Volume of water to add = 15 mL − 6 mL = 9 mL

The final volume must be 15 mL. Because the initial volume is 6 mL, 9 mL of water must be added to the original stock solution.

b

2. At a pressure of 1.00 atm and a temperature of 20°C, 1.72 g CO_2 will dissolve in 1 L of water. How much CO_2 will dissolve if the pressure is raised to 1.35 atm and the temperature stays the same?

a. 2.32 g/L
b. 1.27 g/L
c. 0.785 g/L
d. 0.431 g/L

$S_1/P_1 = S_2/P_2$

$S_2 = S_1(P_2/P_1) = 1.72\ g/L(1.35\ \cancel{atm}/1.00\ \cancel{atm}) = 2.32\ g/L$

Because the volume is 1 L, 2.32 g will dissolve.

a

3. What is the molality of a solution containing 0.25 g of dichlorobenzene ($C_6H_4Cl_2$) dissolved in 10.0 g of cyclohexane (C_6H_{12})?

a. 0.17 mol/kg
b. 0.014 mol/kg
c. 0.025 mol/kg
d. 0.00017 mol/kg

molality = moles of solute/kilograms of solvent

molar mass of $C_6H_4Cl_2$ = 146.91 g $C_6H_4Cl_2$ /mol

$$\text{kilograms } C_6H_{12} = 10.0\ \cancel{g} \times \frac{1\ kg}{1000\ \cancel{g}} = 0.0100\ kg$$

$$\text{mol } C_6H_4Cl_2 = 0.25\ \cancel{g\ C_6H_4Cl_2} \times \frac{1\ mol\ C_6H_4Cl_2}{146.91\ \cancel{g\ C_6H_4Cl_2}}$$

$= 0.0017$ mol

molality = 0.0017 mol/0.0100 kg = 0.17 mol/kg

a

4. If 1 mole of each of the solutes listed below is dissolved in 1 L of water, which solute will have the greatest effect on the vapor pressure of its respective solution?

a. KBr
b. $C_6H_{12}O_6$
c. $MgCl_2$
d. $CaSO_4$

c

5. What volume of a 0.125*M* $NiCl_2$ solution contains 3.25 g $NiCl_2$?

a. 406 mL
b. 201 mL
c. 38.5 mL
d. 26.0 mL

molarity = moles of solute/liter solution

liter solution = moles of solute/molarity

moles of solute = moles of $NiCl_2$

$$\text{moles of } NiCl_2 = 3.25\ \cancel{g\ NiCl_2} \times \frac{1\ mol\ NiCl_2}{129.62\ \cancel{g\ NiCl_2}}$$

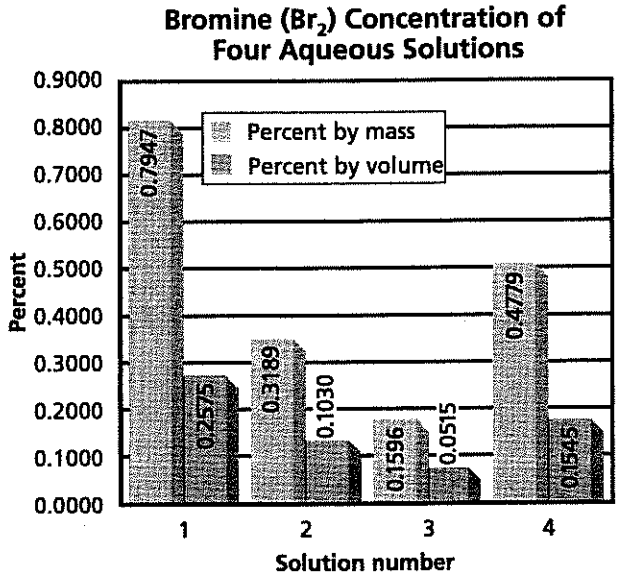
$= 0.0251$ mol

$$\text{liters solution} = 0.0251\ \cancel{mol\ NiCl_2} \times \frac{1\ L\ solution}{0.125\ \cancel{mol\ NiCl_2}}$$

liters solution = 0.2008 L = 201 mL

b

Interpreting Graphs Use the graph to answer questions 6–8.



6. The volume of bromine (Br_2) in 7.000 L of Solution 1 is _____ .

a. 55.63 mL
b. 8.808 mL
c. 18.03 mL
d. 27.18 mL

Volume of Br_2 = (7 L)(0.2575%)

Volume of Br_2 = (7 L)(0.002575) = 0.0180 L = 18.03 mL

c

7. How many grams of Br_2 are in 55.00 g of Solution 4?

a. 3.560 g
b. 0.084 98 g
c. 1.151 g
d. 0.2628 g

Mass of Br_2 = (55.0 g)(0.4779%)

Mass of Br_2 = (55.00 g)(0.004779) = 0.2628 g

d

8. Which of the following relationships is true?

a. 2 × Concentration of solution 2 = Concentration of solution 3

b. 0.5 × Concentration of solution 2 = Concentration of solution 3

c. Concentration of solution 2 = 0.25 × Concentration of solution 3

d. Concentration of solution 2 = 3 × Concentration of solution 3

b

9. All of the following are colligative properties EXCEPT _____ .

a. boiling point elevation
b. freezing point depression
c. vapor pressure increase
d. osmotic pressure

c

10. Colloids can be distinguished from solutions because _____ .

a. dilute colloids have particles that can be seen with the naked eye
b. colloid particles are much smaller than solvated particles
c. dispersed colloid particles will settle out of the mixture in time
d. colloids will scatter light beams that are shone through them

d