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**WS 13.1 Solutions - Saturated, Unsaturated & Supersaturated**

You may need to refer to pages 445 to 452 in text.

1. Do all solutions involve liquids? Explain.

2. All solutions contain two components. Name and describe these two components.

3. What does the expression “like dissolves like” mean?

4. Based on question #3, what might you look at to determine if a substance will dissolve in water?

5. In section 13.3 the text describes what happens when something dissolves. Explain why dissolving is a competition.

6. What is solubility? What units would solubility have?

7. What is a saturated solution? Compare this to an unsaturated solution and a supersaturated solution?

8. If I try to dissolve more solid into a saturated solution what will happen?

9. If I disturb a supersaturated solution, what will happen?

10. What is the difference between an electrolyte and a nonelectrolyte? (This should sound very familiar to you.)

11. What effect does temperature have on most solids? Why do I say most?

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**WS 13.2 Concentration Problems**

***Parts per hundred (or million) and Mass %***

1. Calculate the concentration of each of the following solutions in mass percent. (Do not express in sig figs). Assume that water is the solvent in each case.

 a. 5.0 g in 100 g **(4.8%)**

b. 57.2 g in 45 ml **(56%)**

2. What mass of sodium chloride would be present in 100 grams of a 1.5% solution? **(1.5 g NaCl)**

3. If 87 grams of solute is dissolved in 153 grams of solvent, calculate the concentration in parts per hundred. **(56.9 pph)**

4. If 5.4 grams of solute is dissolved in 1300 grams of solvent, calculate the concentration in parts per million. **(4154 ppm)**

5. What mass of solute is present in 50 ml of a 2.8% solution? **(1.4 g)**

6. What volume of water will be necessary to prepare a 5 ppt solution using 14 grams of solute? **(2800 ml)**

7. A 500 L sample of air with a density of 1.0 g/L was found to contain 2.4  10-3 grams of the pollutant SO2. What is the concentration of the SO2 in the air, expressed in percent by mass and in parts per million? **(.00048%, 4.8 ppm)**

8. Mercury is an extremely toxic substance that deactivates enzyme molecules that promote biochemical reactions. A 25.0 gram sample of tuna fish taken from a large shipment was analyzed for this substance and found to contain 2.1  10-5 grams of mercury. By law, foods having a mercury content above 0.50 ppm cannot be sold. Determine whether this shipment of tuna must be confiscated. **(0.84 ppm, yes)**

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***Molarity***

9. Calculate the molarity for each of the following solutions:

a. 54 grams of NaOH in 1.0 L solution **(1.35 M)** b. 192.3 grams of KClO3 in 1.0 L solution **(1.57 M)**

c. 7.8 g of potassium hydroxide in 500 ml of solution **(.28 M)**

10. Calculate the molarity of a solution made from dissolving 328 grams of calcium nitrate in 500 ml of solution. **(4.0 M)**

11. Calculate the number of grams of citric acid, C6H8O7, needed to make 2500 ml of

0.4M citric acid solution. **(192 g)**

12. How many grams of sodium hydroxide would you have to dissolve in 250 ml of solution to make a 0.5M solution of NaOH. **(5.0 g)**

13. How many liters of solution are required to make a 0.2M solution of sodium sulfide, Na2S, using 200.0 g of Na2S? **(12.8 L)**

14. Calculate the number of grams of sodium chloride needed to make 100 ml of 3M NaCl solution. **(17.6 g)**

15. How many moles of solute are in:

a.250 ml of 0.100M KCl **(.025mol)**

b.1.65 L of 1.40M HClO4**(2.3 mol)**

c.0.0250 L of 0.0100 M HC2H3O2 **(.00025 mol)**



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**WS 13.3 Concentration Problems (Molality & Mole Fraction)**

***Molality***

16. Suppose you wanted to dissolve 294.3 g H2SO4 in 1.000 kg H2O. a. What is the solute?

b. What is the solvent?

c. What is the molality of this solution? **(3.000 m)**

17. What is the molality of a solution of 63.0 grams HNO3 in 0.250 kg H2O? **(4.00 m)**

18. Determine the number of grams of solute needed to make a 4.50 *m* solution of

H2SO4 in 1.00 kg H2O. **(441.5 g)**

19. A solution is prepared by dissolving 17.1 grams of sucrose, C12H22O11 in 275 g of

H2O. What is the molality of that solution? **(0.182 m)**

20. How many kilograms of H2O must be added to 75.5 grams of Ca(NO3)2 to form a

0.500 *m* solution? **(0.920 kg)**

21. A solution made from ethanol, C2H5OH and water is 1.75 *m*. How many grams of

C2H5OH are contained per 250 g of water? **(20.1 g)**

*22.* Calculate the molality when 75.0 grams of MgCl2 is dissolved in 500.0 g of solvent. **(1.57 m)**

***Mole Fraction***

1. Calculate the mole fraction for each component in the following:

a. 12.3 grams of C4H4O in 100 grams of C2H6O **(0.077, 0.923)**

b. 156 grams of C23H33O11 in 300 grams of H2O **(0.019, 0.981)**

c. 75.6 grams of C10H8 in 650 grams of C4H10O **(0.063, 0.937)**

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2. Calculate the mole fraction for each component in the following solutions:

a. 67.4 grams of C9H7N in 200 grams C2H6O **(0.1073, 0.8927)**

b. 5.48 g of C5H10O5 and 3.15 grams of CH6N4O in 21.2 g water **(0.029, 0.028, 0.943)**

3. A 100 gram sample of rubbing alcohol contains 65.0 grams of isopropyl alcohol., C3H7OH and 35 grams of water. What is the mole fraction of isopropyl alcohol in the solution? **(0.3578)**

4. A bleaching solution contains sodium hypochlorite, NaClO, dissolved in water.

The solution is 0.650 m NaClO. What is the mole fraction of sodium hypochlorite? **(0.0116)**

5. An automobile antifreeze solution contains 2.61 kg of ethylene glycol, CH2OHCH2OH, and 2.00 kg of water. Find the mole fraction of ethylene glycol in this solution. What is the mole fraction of water? **(0.2748, 0.7252)**

6. An antiseptic solution contains hydrogen peroxide H2O2 in water. The solution is

0.655 m H2O2. What is the mole fraction of hydrogen peroxide? **(0.0117)**

***Dilution***

7. A stock solution of 1.00 M NaCl is available. How many milliliters are needed to make 100.0 mL of 0.750 M **(75 ml)**

8. What volume of 0.250 M KCl is needed to make 100.0 mL of 0.100 M solution? **(40 ml)**

9. Concentrated H2SO4 is 18.0 M. What volume is needed to make 2.00 L of 1.00 M

solution? **(111.1 ml)**

10. Concentrated HCl is 12.0 M. What volume is needed to make 2.00 L of 1.00 M

solution? **(166.7 ml)**

11. A 0.500 M solution is to be diluted to 500.0 mL of a 0.150 M solution. How many mL of the 0.500 M solution are required? **(150 ml)**

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**WS 13.4 Concentration Problems (Mixed Problems)**

1. Calculate the molarity of:

a. 32.7 grams of ammonium bromide in 250 ml of solution. **(1.34 M)**

b. 1.2 grams of hydrochloric acid in 150 ml of solution. **(0.22 M)**

2. What are the molality and percent solution of CuCl2 in a solution prepared by dissolving 0.30 mol of CuCl2 in 40.0 mol of H2O? **(0.42 m, 5.31%)**

3. A sample of drinking water was found to be severely contaminated with chloroform, CHCl3, a known carcinogen. The level of contamination was 12.4 ppm by weight. Express this in percent solution as well as in molarity. **(0.00124 %, 0.000104 M)**

4. Calculate the final concentration if 2.00 L of 3.00 M NaCl, 4.00 L of 1.50 M NaCl and 4.00 L of water are mixed. Assume there is no volume contraction upon mixing. **(1.2 M)**

5. Concentrated sulfuric acid is 96% H2SO4 by weight. What is the molality of the

H2SO4? **(244.6 m)**

6. An antifreeze solution is prepared from 2122.6 grams of ethylene glycol, C2H4(OH)2, and 200 grams of water. Its density is 1.072 g/ml. Calculate the molality and molarity of the solution. **(171.2 m, 15.8 M)**

7. How many moles of NaOH are contained in 65.0 ml of a 2.20 M solution of

NaOH? **(0.143 moles)**

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8. What mass of solute will be necessary to prepare 1500 grams of a 2 ppt solution. **(3 g)**

9. Calculate the molality of a solution made by dissolving 26.50 g of sodium carbonate, in 330 ml of water. **(0.76 m)**

10. If I make a solution by adding 83 grams of sodium hydroxide to 750 mL of water, calculate the mole fraction of NaOH in this solution. **(0.0474)**

11. How many grams of Na2CO3 are required to prepare 300 ml of a 0.150 M

solution? **(4.8 g)**

12. How many grams of Ba(OH)2 are required to prepare a 250 ml solution with a concentration of 0.300 M. **(12.9 g)**

13. 100.0 grams of sucrose (C12H22O11, mol. wt. = 342.3 g/mol) is dissolved in 1.50 L

of water. What is the molality? **(0.19 M)**

14. How many grams of solute are needed to make 2.50 L of a 1.75 M solution of

Ba(NO3)2? **(1143.2 g)**

15. A stock solution of 10.0 M NaOH is prepared. From this solution, you need to make 250.0 mL of 0.375 M solution. How many mL will be required? **(9.4 ml)**

16. 2.00 L of 0.800 M NaNO3 must be prepared from a solution known to be 1.50 M

in concentration. How many mL are required? **(1066.7 ml)**

17. A solution is made by dissolving 26.42 grams of (NH4)2SO4 in enough H2O to make 50.0 mL of solution. What is the molarity of this solution? **(4.0 M)**

18. 49.8 grams of KI is dissolved in 1.00 kg of solvent. What is the molality? **(0.3 m)**

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**WS 13.5 Solution Stoichiometry**

*For each problem, use the equation provided to answer the following:*

**1. \_Na2S2O3 (aq) + I2 (s)**   **\_NaI (aq) + Na2S4O6 (aq)**

a. How many grams of iodine (I2) will react with 200 ml of a 2M solution of

Na2S2O3? **(50.8 g)**

**2. \_Fe (s) + \_HCl (aq)**  **H2 (g) + FeCl2 (s)**

a. How many grams of iron are consumed when reacted with 50 ml of a

0.5M solution of HCl? **(0.70 g)**

b. How many grams of FeCl2 are produced when 120 ml of 2.5M solution of

HCl is reacted with excess Fe? **(19.0 g)**

**3. \_PbO2 (s) + HCl (aq)**  **H2O (l) + PbCl2 (s) + \_Cl2 (g)**

a. Calculate the moles of lead chloride produced when reacting 1.75 L of

0.5M of HCl with excess lead oxide **(0.22 mol)**

b. Determine the mass of lead oxide consumed when reacting with the 1.75

L of 0.5 M HCl above. **(52.3 g)**

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**4. \_Fe2O3 (s) + \_H2SO4 (aq)**   **\_Fe2(SO4)3 (aq) + \_H2O (l)**

a. How many grams of iron oxide are needed to completely react with 50 ml of 2M H2SO4? **(5.3 g)**

**5. \_HCl (aq) + \_Cr (s)**   **CrCl2 (aq) + \_H2 (g)**

a. Determine the molarity of HCl used, if 500 ml is reacted and 32.5 L of hydrogen gas are produced. Assume STP. **(5.8 M)**

**6. \_Al (s) + \_Fe3O4 (aq)**

a. Finish the equation, and then calculate the mass of iron produced, if

0.075L of a 2.5 M iron oxide solution is reacted with excess aluminum. **(31.4 g)**

**7. \_ZnS (s) + \_HCl (aq)** 

a. Calculate the liters of hydrogen sulfide produced, if 777 ml of a 0.50 M solution of hydrochloric acid reacts with excess zinc sulfide. (Assume STP). **(4.4 L)**

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**WS 13.6 Solution Stoichiometry**

1. If you mix 200 ml of 0.100 M Pb(NO3)2 and 300 ml of 0.200 M MgCl2, how much

PbCl2 precipitate will you form? **(5.6 g)**

2. How many moles of lead chromate, PbCrO4, the pigment "chrome yellow", often used by artists, can be produced by addition of excess sodium chromate, Na2CrO4, to 25 mL of a 0.493 M solution of lead(II) nitrate, Pb(NO3)2? **(0.012 mol)**

3. What mass of the active metal magnesium is required to react exactly with the hydrochloric acid in a 125.0 mL sample of a 0.2110 M solution of HCl? **(0.32 g)**

4. What volume, in L, of 0.0385 M ScCl2 is required to react with 22.0 mL of 0.130M AgNO3? **(0.0371 L)**

5. What volume, in mL, of 0.0250 M HCl is required to react completely with 15.8 mL of 0.0148 M Sr(OH)2? **(18.7 ml)**

6. A 50.0 mL sample of FeCl2 is titrated with 14.32 mL of 0.0163 M K2Cr2O7 to reach the end point corresponding to the following reaction. What is the molarity of FeCl2? **(0.0047 M)**

FeCl2 + K2Cr2O7  FeCr2O7 + KCl

7. The titration of 25.0 mL of potassium dichromate solution with 0.0350 M FeCl2 solution (see equation above) requires 27.5 mL of the iron chloride solution. What is the molarity of the potassium dichromate? **(0.0385 M)**

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8. A 25.00 mL sample of sulfuric acid solution from an automobile battery reacts exactly with 87.42 mL of a 1.95 M solution of sodium hydroxide, NaOH. What is the molar concentration of the battery acid? **(3.41 M)**

H2SO4(aq) + NaOH(aq)  Na2SO4(aq) + H2O(l)

9. If 25.00 mL HCl acid with a concentration of 0.1234 M is neutralized by 23.45 mL

of NaOH, what is the concentration of the base? **(0.13 M)**

10. Given a solution containing 0.242 g of barium chloride, BaCl2, how many mL of

0.0581 M H2SO4 will completely precipitate the barium ions, Ba2+? **(20.0 ml)**

11. How many grams of aluminum are needed to react with excess 0.65 molar solution of copper II sulfate to produce 2 moles of copper? **(36.0 g)**

12. If 200 milliliters of 0.4 molar Na2SO4 react with excess Ca(NO3)2, what is the mass in grams of CaSO4 produced? **(10.9 g)**

13. 93.0 mL of 0.150 M magnesium hydroxide is added to 57.0 mL of 0.4 M nitric acid. (Magnesium nitrate and water are formed) What is the concentration of the magnesium nitrate after the reaction? **(0.076 M)**

14. Chlorine gas is bubbled into 250 mL of 0.50 M potassium bromide solution. This produces potassium chloride and bromine gas. The bromine dissolves completely in the water. What is the concentration of bromine? **(0.25 M)**

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**WS 13.7 Colligative Properties: Boiling Point Elevation and Freezing Point Depression**

1. What is the freezing point depression of water in a solution of 17.1 grams of sucrose, C12H22O11 and 200 grams of water. What is the actual freezing point of the solution? **(-0.465 0C)**

2. A water solution containing an unknown quantity of a nonelectrolyte solute is found to have a freezing point of -0.23 degrees. What is the molal concentration of the solution? **(0.12 m)**

3. If 0.500 mol of a nonelectrolyte solute are dissolved in 500.0 grams of camphor which has a melting point of 180C, what is the freezing point of the solution? The Kf for camphor is 40 C/*m*. **(140 0C)**

4. The freezing point of an aqueous solution that contains a nonelectrolyte is –9.0 degrees Celsius.

a. What is the freezing-point depression of the solution? **(-9.0 0C)**

b. What is the molal concentration of the solution? **(4.8 m)**

5. What is the boiling point elevation of a solution made from 20.0 grams of a nonelectrolyte solute and 400.0 grams of water. The molar mass of the solute is

62.0 grams. **(0.41 0C)**

6. A solution contains 50.0 grams of sucrose, C12H22O11, a nonelectrolyte, dissolved in 500.0 grams of water. What is the boiling point elevation? **(0.15 0C)**

7. A solution contains 450.0 grams of sucrose, a nonelectrolyte, dissolved in 250 g of water. What is the boiling point of the solution? **(102.7 0C)**

8. If the boiling point elevation of an aqueous solution containing a nonvolatile electrolyte is 1.02 degrees, what is the molality of the solution? **(1.99 m)**

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9. What is the expected change in freezing point of water for an aqueous solution that is 0.015 *m*AlCl3? **(-0.11 0C)**

10. What is the expected freezing point of a solution containing 85.0 grams of NaCl dissolved in 450g of water? **(-12.0 0C)**

11. The change in the boiling point of water for an aqueous solution of potassium iodide is 0.65 degrees. Determine the apparent molal concentration of potassium iodide. **(0.63 m)**

12. The freezing point of an aqueous solution of barium nitrate is –2.65 degrees.

Determine the apparent molal concentration of barium nitrate. **(0.47 m)**

13. Calculate the expected freezing point of a solution containing 1.00 kg of H2O and

0.250 mol of NaCl. **(-0.93 0C)**

14. A 0.205 g sample of white phosphorus was dissolved in 25 grams of carbon disulfide, CS2. The boiling point elevation of the carbon disulfide solution was found to be 0.159 Celsius. What is the molecular weight of the phosphorus in solution? Kb = 2.34 0C/m. **(120.7 g/mol)**

15. Safrole is contained in oil of sassafras and was once used to flavor root beer. A

2.39g sample of safrole was dissolved in 103.0 g of diphenyl ether. The solution had a melting point of 25.7  C. Calculate the molecular weight of safrole. The freezing point of pure diphenyl ether is 26.84 C, and the freezing point depression constant, Kf, is 8.00 C/m. **(162.8 g/mol)**

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**WS 13.8 Solutions Review/Mixed Problems**

1. What is the concentration, in parts per thousand, if 35 grams of NaNO3 is dissolved in 250 ml of water? **(140 ppt)**

2. 100 ml of chlorine is added to a 350,000 liter swimming pool. Calculate the concentration in percent solution and parts per million. **(.000029%, .29 ppm)**

3. The metal, sodium, comprises approximately 2.6% of the earth’s crust. What is

this concentration in parts per million? **(26,000 ppm)**

4. Calculate the molarity of a solution, if 500 ml contains 125 grams of CaSO4. **(1.84 M)**

5. How many grams of silver nitrate does a 330 ml sample of 1.5M silver nitrate contain? **(84.1 g)**

6. Determine the molality of a solution containing 79.5 grams of silver iodide dissolved in 250 ml of water. **(1.35m)**

7. How many grams would you find in a 1200 ml aqueous solution of NaCl with a concentration of 0.5M? **(35.1 g)**

8. Calculate the freezing point depression when 2.5 moles of a nonelectrolyte is added to 1250 ml of water. **(-3.7 0C)**

9. Determine the boiling point of a solution consisting of 500 ml of water and 125 grams of MgCl2. **(104.0 0C)**

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10. Calculate the molecular weight of a compound, if 0.2 kg of the substance is added to 500 ml of water, resulting in a freezing point of – 2.3C. **(323.5 g/mol)**

11. The freezing point of an aqueous solution of strontium chloride is –6.65 degrees.

Determine the apparent molal concentration of strontium chloride. **(1.19*m*)**



12. A solution containing a nonelectrolyte (MW = 137 g/mole) has a boiling point of

102.8C. Calculate the grams of solute present in a 500 g sample. **(374.6 g)**

13. Describe how to prepare 750 ml of a 2 M solution, using a stock solution with a concentration of 12 M. **(.125 L of 12 M solution)**.

14. What volume of 0.27 M sodium hydroxide is needed to react with 29.5 ml of

0.55 M phosphoric acid? **(180.3 ml)**

15. 95.0 mL of 0.55 M sulfuric acid is put on an excess of zinc. This produces zinc sulfate and hydrogen. How many grams of zinc sulfate are made? **(8.4 g)**

16. 27.6 mL of a 0.190 M solution of silver nitrate and 15.4 mL of an unknown (but excess) amount of magnesium chloride combine to make a white precipitate silver chloride and some dissolved magnesium nitrate.

a. How many moles of silver chloride are made? **(0.0052 mol)**

b. How many grams of silver chloride is that? **(0.75 g)**

c. How many moles of magnesium nitrate are made? **(0.0026 mol)**

d. What is the concentration of magnesium nitrate in the final solution? **(0.06 M)**

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