SUPPLEMENTARY CONCENTRATION PROBLEMS

1. Whole milk usually contains 5.0% milk fat by volume/volume. If you drink a 250.0 mL glass of whole milk, how much milk fat have you consumed?

2. A solution contains 5.30 g of potassium chloride in 255.5 g of water. Calculate the weight/weight percent of solute in this solution. (Don't ignore the mass of the solute).

3. Vinegar is sold as a 5.0% (V/V) solution of acetic acid in water. Assuming that liquid volumes are additive, what volume of water must be added to 15 mL of acetic acid to produce synthetic vinegar?

4. Electrician's solder is 60.0% tin and 40.0% lead by mass. What is the mole ratio of the two elements?

5. Evaporation of a 23.47 g sample of slush yields a 4.58 g $CaCl_2$ salt residue. Calculate the weight/weight percentage of calcium chloride in the slush.

6. The recommended W/V percentage for a TSP solution used to clean walls before wallpapering is 1.7%. What mass of TSP is needed to make 2.0 L of this solution?

$4.5\% = \frac{x}{x+225} \times 100\%$

$4.5(x+225) = 100x$

$4.5x + 4.5(225) = 100x$

$95.5x = 1012.5$

$x = 10.602\text{g} \times .789 = 8.4$

7. The density of ethanol is 0.789 g/mL. How many grams of ethanol should be mixed with 225 mL of water to make a 4.5% (v/v) mixture? (8.4 g)

$4.5\% = \frac{x \cdot 100}{x+225}$

$4.5x + 225(4.5) = 100x$

$95.5x = 1,012.5$

$x = 10.602\text{g} \times .789 \times 8.4\text{g}$

8. Ammonium nitrate, which is a major ingredient in fertilizers releases nitrate ion into the water. The World Health Organization has set an upper limit of 10.0 ppm for infants. If an infant has a mass of 4.0 kg, what is the maximum allowable mass of nitrate ions that would be permitted in the infant's body tissues?

$C = \frac{n}{V}$

Concentrations and Dilutions Worksheet

1. What is the molarity of a solution in which 0.45 grams of sodium nitrate are dissolved in 265 mL of solution. (0.020 M)

$n = C \times V$

2. What will the volume of a 0.50 M solution be if it contains 25 grams of calcium hydroxide? (680 mL)

3. How many grams of ammonia are present in 5.0 L of a 0.050 M solution? (4.3 grams)

4. How many grams of beryllium chloride are needed to make 125 mL of a 0.0500 M solution? (0.500 grams)

5. If 25.0 mL of water is added to 125 mL of a 0.15 M NaOH solution, what will the concentration of the diluted solution be? (0.125 M)

$C_1V_1 = C_2V_2$

6. If 100.0 mL of water is added to a sample of 0.150 M NaOH solution until the final volume is 150.0 mL, what will the molarity of the diluted solution be? (0.0500 M)

7. How much 0.0500 M HCl solution can be made by diluting 250.0 mL of 10.0 M HCl? (50.0 L)

8. If a scientist has 345 mL of a 1.5 M NaCl solution and she boils the water until the volume of the solution is 250. mL, what will the final concentration of the solution be? (2.07 M)

9. How much water would I need to add to 500. mL of a 2.40 M KCl solution to make a 1.00 M solution? (700. mL)

10. A clear solution is made from 1.5 L of 0.40 M $MgCl_2$ and 0.50 L of water. Calculate the resultant concentration of chloride ion. (0.60 M)

11. The concentration of acetic acid, CH_3COOH , in a sample of vinegar is determined to be 0.878 mol/L. If the density of the acetic acid is 1.045 g/mL, calculate the volume/volume percent of acetic acid in the vinegar sample. (5.05 % V/V)

SUPPLEMENTARY CONCENTRATION PROBLEMS

1. Whole milk usually contains 5.0% milk fat by volume/volume. If you drink a 250.0 mL glass of whole milk, how much milk fat have you consumed?

$$5.0\,\%\ \text{V/V} = \frac{V_{fat}}{250.0\ \text{mL milk}} \times 100$$

$$\frac{5.0\ \text{ml fat}}{100\ \text{ml milk}} = \frac{V_{fat}}{250.0\ \text{mL milk}}$$

$$V_{fat} = 250.0\ \text{mL milk} \times \frac{5.0\ \text{ml fat}}{100\ \text{ml milk}} = 12.5\ \text{mL} = 13\ \text{mL fat}$$

2. A solution contains 5.30 g of potassium chloride in 255.5 g of water. Calculate the weight/weight percent of solute in this solution. (Don't ignore the mass of the solute).

$$\%\ \text{W/W KCl} = \frac{5.3\ \text{g KCl}}{255.5\ \text{g water} + 5.3\ \text{g KCl}} \times 100 = 2.0\,\%\ \text{W/W KCl}$$

3. Vinegar is sold as a 5.0% (V/V) solution of acetic acid in water. Assuming that liquid volumes are additive, what volume of water must be added to 15 mL of acetic acid to produce synthetic vinegar?

$$5.0\,\%\ \text{V/V} = \frac{15\ \text{mL acetic acid}}{V_{solution}} \times 100$$

$$\frac{5.0\ \text{mL acetic acid}}{100\ \text{mL vinegar}} = \frac{15\ \text{mL acetic acid}}{V_{solution}}$$

$$V_{solution} = V_{H_2O\ +\ \text{acetic acid}} = 300\ \text{mL vinegar}$$

$$\therefore\ V_{H_2O} = 300\ \text{mL} - 15\ \text{mL} = 285\ \text{mL or } 0.29\ \text{L}$$

4. Electrician's solder is 60.0% tin and 40.0% lead by mass. What is the mole ratio of the two elements?

$$n_{Sn} = 60.0\ \text{g Sn} \times \frac{1\ \text{mol Sn}}{118.69\ \text{g Sn}} = 0.506\ \text{mol Sn}$$

$$n_{Pb} = 40.0\ \text{g Pb} \times \frac{1\ \text{mol Pb}}{207.19\ \text{g Pb}} = 0.193\ \text{mol Pb}$$

$$\text{ratio} = \frac{0.506\ \text{mol Sn}}{0.193\ \text{mol Pb}} = \frac{2.62\ \text{Sn}}{1\ \text{Pb}} \qquad \therefore\ 2.62\ \text{Sn} : 1\ \text{Pb}$$

5. Evaporation of a 23.47 g sample of slush yields a 4.58 g $CaCl_2$ salt residue. Calculate the weight/weight percentage of calcium chloride in the slush.

$$\% \text{ W/W salt} = \frac{4.58 \text{ g salt}}{23.47 \text{ g slush}} \times 100$$

$$= 19.5 \% \text{ W/W salt}$$

$$\therefore \text{the } \% \text{ W/W is } 19.5\% \ CaCl_2$$

6. The recommended W/V percentage for a TSP solution used to clean walls before wallpapering is 1.7%. What mass of TSP is needed to make 2.0 L of this solution?

$$m_{TSP} = 2000 \text{ mL solution} \times \frac{1.7 \text{ g TSP}}{100 \text{ mL solution}}$$

$$= 34 \text{ g TSP}$$

7. The density of ethanol is 0.789 g/mL. How many grams of ethanol should be mixed with 225 mL of water to make a 4.5% (v/v) mixture? (8.4 g)

$$D = 0.789 \text{ g/mL} = \frac{m}{V}; \quad m = DV$$

$$\% \text{ V/V} = \frac{V_{solute}}{V_{solute} + V_{solvent}} \times 100$$

$$4.5 \% \text{ V/V} = \frac{V_{solute}}{V_{solute} + 225 \text{ mL}} \times 100$$

$$\frac{4.5 \text{ mL}}{100 \text{ mL}} = \frac{V_{solute}}{V_{solute} + 225 \text{ mL}}$$

$$0.045 (V_{solute} + 225 \text{ mL}) = V_{solute} \; ; \; 0.045 \, V_{solute} + 10.125 \text{ mL} = V_{solute}$$

$$(1 - 0.045) V_{solute} = 10.125 \text{ mL} \; ; \quad V_{solute} = 10.60 \text{ mL}$$

$$\text{then} \quad m = DV = 0.789 \text{ g} \cdot \text{mL}^{-1} \times 10.60 \text{ mL} = 8.4 \text{ g}$$

8. Ammonium nitrate, which is a major ingredient in fertilizers releases nitrate ion into the water. The World Health Organization has set an upper limit of 10.0 ppm for infants. If an infant has a mass of 4.0 kg, what is the maximum allowable mass of nitrate ions that would be permitted in the infant's body tissues?

$$m_{nitrate} = 4.0\,kg\ infant\ x\ \frac{10\,mg\ nitrate}{1\,kg\ infant} = 40\,mg\ nitrate$$

Concentrations and Dilutions Worksheet

1. What is the molarity of a solution in which 0.45 grams of sodium nitrate are dissolved in 265 mL of solution. (0.020 M)

$m_{NaNO_3} = 0.45\,g$; $M_{NaNO_3} = 85.00\,g/mol$; $V = 265\,mL = 0.265\,L$

$C = ?$

$$C = \frac{n}{V} = \frac{m}{MV}$$

$$C = \frac{0.45\,g}{85.00\,g \cdot mol^{-1} \times 0.265\,L}$$

$$= 0.020\,mol/L = 0.020\,M$$

2. What will the volume of a 0.50 M solution be if it contains 25 grams of calcium hydroxide? (680 mL)

$m_{Ca(OH)_2} = 0.50\,g$; $M_{Ca(OH)_2} = 74.10\,g/mol$; $C = 0.50\,M = 0.50\,mol/L$

$V = ?$

$$C = \frac{n}{V} = \frac{m}{MV}; \quad V = \frac{m}{MC}$$

$$V = \frac{0.50\,g}{74.10\,g \cdot mol^{-1} \times 0.50\,mol \cdot L^{-1}}$$

$$= 0.675\,L = 680\,mL$$

3. How many grams of ammonia are present in 5.0 L of a 0.050 M solution? (4.3 grams)

$V = 5.0\,L$; $M_{NH_3} = 17.04\,g/mol$; $C = 0.050\,M = 0.050\,mol/L$

$m = ?$

$$C = \frac{n}{V} = \frac{m}{MV}; \quad m = CMV$$

$$m = 0.050\,mol \cdot L^{-1} \times 17.04\,g \cdot mol^{-1} \times 5.0\,L$$

$$= 4.3\,g$$

4. How many grams of beryllium chloride are needed to make 125 mL of a 0.0500 M solution? (0.500 grams)

$$V = 125.0\ \text{mL} = 0.125\ \text{L};\quad M_{BeCl_2} = 79.91\ \text{g/mol};\quad C = 0.05000\ \text{M} = 0.05000\ \text{mol/L}$$

$$m = ?$$

$$C = \frac{n}{V} = \frac{m}{MV};\quad m = CMV$$

$$m = 0.05000\ \text{mol}\cdot\text{L}^{-1}\ \text{x}\ 79.91\ \text{g}\cdot\text{mol}^{-1}\ \text{x}\ 0.125\ \text{L}$$

$$= 0.500\ \text{g}$$

5. If 25.0 mL of water is added to 125 mL of a 0.15 M NaOH solution, what will the concentration of the diluted solution be? (0.125 M)

$$V_1 = 125\ \text{mL} = 0.125\ \text{L};\quad V_2 = 25.0\ \text{mL} + 125\ \text{mL} = 150.\ \text{mL} = 0.150\ \text{L}$$

$$C_1 = 0.15\ \text{M};\quad C_2 = ?$$

$$= 0.15\ \text{mol/L}$$

$$C_1V_1 = C_2V_2\ ;\ C_2 = \frac{C_1V_1}{V_2}$$

$$= \frac{0.15\ \text{mol}\cdot\text{L}^{-1}\ \text{x}\ 0.125\ \text{L}}{0.150\ \text{L}}$$

$$= 0.125\ \text{mol/L} = 0.125\ \text{M}$$

6. If 100.0 mL of water is added to a sample of 0.150 M NaOH solution until the final volume is 150.0 mL, what will the molarity of the diluted solution be? (0.0500 M)

$V_1 = 50.0\ mL = 0.0500\ L$; $V_2 = 150.0\ mL = 0.1500\ L$

$C_1 = 0.150\ M$; $C_2 = ?$

$= 0.150\ mol/L$

$$C_1V_1 = C_2V_2\ ;\ C_2 = \frac{C_1V_1}{V_2}$$

$$= \frac{0.150\ mol \cdot L^{-1} \times 0.0500\ L}{0.150\ L}$$

$$= 0.0500\ mol/L = 0.0500\ M$$

7. How much 0.0500 M HCl solution can be made by diluting 250.0 mL of 10.0 M HCl? (50.0 L)

$V_1 = 250.0\ mL = 0.2500\ L$; $V_2 = ?$

$C_1 = 10.0\ M$; $C_2 = 0.0500\ M$

$= 10.0\ mol/L$ $= 0.0500\ mol/L$

$$C_1V_1 = C_2V_2\ ;\ V_2 = \frac{C_1V_1}{C_2}$$

$$= \frac{10.0\ mol \cdot L^{-1} \times 0.2500\ L}{0.0500\ mol \cdot L^{-1}} = 50.0\ L$$

8. If a scientist has 345 mL of a 1.5 M NaCl solution and she boils the water until the volume of the solution is 250. mL, what will the final concentration of the solution be? (2.07 M)

$V_1 = 345\ mL = 0.345\ L$; $V_2 = 250.\ mL = 0.250\ L$

$C_1 = 1.5\ M$; $C_2 = ?$

$= 1.5\ mol/L$

$$C_1V_1 = C_2V_2\ ;\ C_2 = \frac{C_1V_1}{V_2}$$

$$= \frac{1.5\ mol \cdot L^{-1} \times 0.345\ L}{0.250\ L} = 2.1\ mol/L = 2.1\ M$$

9. How much water would I need to add to 500. mL of a 2.40 M KCl solution to make a 1.00 M solution? (700. mL)

$V_1 = 500.\,mL = 0.500\,L$; $V_2 = 0.500\,L + V_{H_2O}$

$C_1 = 2.40\,M$; $C_2 = 1.00\,M$

$= 2.40\,mol/L$ $= 1.00\,mol/L$

$$C_1V_1 = C_2V_2 \;;\; V_2 = \frac{C_1V_1}{C_2}$$

$$0.500\,L + V_{H_2O} = \frac{2.40\,mol\cdot L^{-1} \times 0.500\,L}{1.00\,mol\cdot L^{-1}}$$

$$V_{H_2O} = 1.20\,L - 0.500\,L = 0.700\,L = 700.\,mL$$

10. A clear solution is made from 1.5 L of 0.40 M $MgCl_2$ and 0.50 L of water. Calculate the resultant concentration of chloride ion. (0.60 M)

$V_1 = 1.5\,L$; $V_2 = 2.0\,L$

$C_1 = 0.40\,M$; $C_2 = ?$

$= 0.40\,mol/L$

$$C_1V_1 = C_2V_2 \;;\; C_2 = \frac{C_1V_1}{V_2}$$

$$= \frac{0.40\,mol\cdot L^{-1} \times 1.5\,L}{2.0\,L} = 0.30\,mol/L = 0.30\,M$$

then $$C_{Cl^{-1}} = \frac{0.30\,mol\,MgCl_2}{1\,L} \times \frac{2\,mol\,Cl^{-1}}{1\,mol\,MgCl_2}$$

$\therefore [Cl^{-1}] = 0.60\,M$

11. The concentration of acetic acid, CH_3COOH , in a sample of vinegar is determined to be 0.878 mol/L. If the density of the acetic acid is 1.045 g/mL, calculate the volume/volume percent of acetic acid in the vinegar sample. (5.05 % V/V)

$C_{vinegar} = 0.878\ mol/L;$

$D_{CH_3COOH} = 1.045\ g/mL = \frac{m}{V};\quad M_{CH_3COOH} = 60.06\ g/mol$

$$D_{vinegar} = \frac{0.878\ mol\ CH_3COOH}{1\ L\ vinegar} \times \frac{60.06\ g}{1\ mol\ CH_3COOH} \times \frac{1\ L}{1000\ mL}$$

$$= 0.05273\ g/mL$$

$$\frac{D_{vinegar}}{D_{CH_3COOH}} = \frac{0.05273\ g/ml}{1.045\ g/ml} \times 100 = 5.05\ \%\ V/V\ acetic\ acid$$

SCH3U Solution Stoichiometry Name:

PART A

1. A solution of limewater, $Ca(OH)_{2\,(aq)}$ is basic. It is used to test for the presence of carbon dioxide. Carbon dioxide is weakly acidic and turns limewater milky. Use a chemical equation to explain what happens during the test. What type of reaction occurs?

2. State the name and formula of the precipitate that forms when aqueous solutions of copper (II) sulfate and sodium carbonate are mixed. Write the net ionic equation for the reaction. Identify the spectator ions.

3. Write a net ionic equation for each double displacement reaction in aqueous solution.

   a. tin (ii) chloride + potassium phosphate

   b. silver nitrate + potassium bromide

   c. nickel (ii) chloride + sodium carbonate

   d. chromium (iii) sulfate + ammonium sulfide

   e. rubidium fluoride + copper(II) sulfate

   f. cobalt(III) bromide + potassium sulfide

   g. barium nitrate + ammonium phosphate

   h. calcium hydroxide + iron(III) chloride

4. Identify the spectator ions for each of the reactions in Question 3.

5. Write a net ionic equation for each reaction. What do you notice about the net ionic equation?
   a. sodium carbonate + hydrochloric acid
   b. acetic acid + calcium hydroxide

PART B

Consider the following equation: $Ca(OH)_{2(s)} + 2\ HCl_{(aq)} \rightarrow CaCl_{2(aq)} + 2\ H_2O_{(l)}$

a) What type of chemical reaction is taking place? _____

b) How many liters of 0.100 M HCl would be required to react completely with 5.00 grams of calcium hydroxide? **[1.35L]**

c) If I combined 15.0 grams of calcium hydroxide with 75.0 mL of 0.500 M HCl, how many grams of calcium chloride would be formed? **[2.08g]**

d) What is the limiting reagent from the reaction in problem #1c? _____ **[HCl]**

f) How many grams of the excess reagent will be left over after the reaction in problem #1c is complete?

[13.6 g of $Ca(OH)_2$]

2. 100.0 mL of 0.200M aqueous potassium hydroxide is mixed with 100.0mL of 0.200M aqueous magnesium nitrate. What mass of magnesium hydroxide is formed? What is/are the concentration of any ions remaining in the solution?

[0.583g, $[K^+]$= 0.1 M , $[Mg^{2+}$ = 0.05M]

3. If you mix 200 ml of 0.100 M $Pb(NO_3)_2$ and 300 ml of 0.200 M $MgCl_2$, how much $PbCl_2$ precipitate will you form?

[5.55 g]

4. How many grams of aluminum are required to react with 35 mL of 2.0 M hydrochloric acid, HCl? **[0.63g]**

   __ HCl + __ Al _ __ $AlCl_3$ + __ H_2

If 45 mL of a 1.5 *M* AgNO3 is added to KCl how many grams of AgCl can be formed? **[9.7g]**

__ $AgNO_3$ + __ KCl _ __ AgCl + __ KNO_3

6. How many liters of a 0.75 M solution of $Ca(NO_3)_2$ will be required to react with 148 g of Na_2CO_3? **[1.86L]**
__ $Ca(NO_3)_2$ + __ Na_2CO_3 _ __ $CaCO_3$ + __ $NaNO_3$

7. How many liters of a 3.0 M H3PO4 solution are required to react with 4.5 g of zinc?**[0.015L]**
__ H_3PO_4 + __ Zn _ __ $Zn_3(PO_4)_2$ + __ H_2

8. How many milliliters of 0.10 M $Pb(NO_3)_2$ are required to react with 75 mL of 0.20 M NaI? **[0.075L]**
__ $Pb(NO_3)_2$ + __ NaI _ __ PbI_2 + __ $NaNO_3$

9. How many grams of solid BaSO4 will form when Na2SO4 reacts with 25 mL of 0.50 M $Ba(NO_3)_2$? **[2.9 g]**
__ $Ba(NO_3)_2$ + __ Na_2SO_4 _ __ $BaSO_4$ + __ $NaNO_3$

10. If 525 mL of 0.80 M HCl solution is neutralized with 315 mL of Sr(OH)2 solution what is the molarity of the $Sr(OH)_2$?
__ HCl + __ $Sr(OH)_2$ _ __ $SrCl_2$ + __ H_2O **[0.67M]**

Stoichiometry Involving Solutions Worksheet

1. Calculate the number of mL of 2.00 M HNO_3 solution required to react with 216 grams of Ag according to the equation.**[1.33L]**

   $3\ Ag_{(s)} + 4\ HNO_{3(aq)} \text{ ---------> } 3\ AgNO_{3(aq)} + NO_{(g)} + 2\ H_2O_{(l)}$

2. Calculate in mL the volume of 0.500 M NaOH required to react with 3.0 grams of acetic acid. **[100mL]**
   The equation is:

   $NaOH_{(aq)} + HC_2H_3O_{2(aq)} \text{ -------> } NaC_2H_3O_{2(aq)} + H_2O_{(l)}$

3. Calculate the number of grams of AgCl formed when 0.200 L of 0.200 M $AgNO_3$ reacts with an excess of $CaCl_2$. Tl equation is: **[5.73g]**

   $2\ AgNO_{3(aq)} + CaCl_{2(aq)} \text{ -------> } 2\ AgCl_{(s)} + Ca(NO_3)_{2(aq)}$

4. Calculate the mass of AgCl formed when an excess of 0.100 M solution of NaCl is added to 0.100 L of 0.200 M $AgNO_3$.**[2.87g]**

5. Calculate:

   a) the mass of $BaSO_4$ formed when excess 0.200 M Na_2SO_4 solution is added to 0.500 L of 0.500 M $BaCl_2$ solution, and **[58.3 g]**

   b) the minimum volume of the Na_2SO_4 solution needed to precipitate the Ba^{2+} ions from the $BaCl_2$ solution. **[1.25L]**

6. To neutralize the acid in 10.0 mL of 18.0 M H_2SO_4 that was accidentally spilled on a laboratory bench top, solid sodium bicarbonate was used. The container of sodium bicarbonate was known to weigh 155.0 g before this use and out of curiosity its mass was measured as 144.5 g afterwards. The reaction that neutralizes sulphuric acid this way is as follows.

   $H_2SO_4 + 2\ NaHCO_3 \text{ --------> } Na_2SO_4 + 2\ CO_2 + 2\ H_2O$

   Was sufficient sodium bicarbonate used? Calculate the limiting reactant and the maximum yield in grams of sodium sulphate. **[$NaHCO_3$- LF, m= 8.73g]**

7. Barium nitrate and potassium sulphate solutions react and form a precipitate. What is the precipitate? How many mL of 0.40 M $Ba(NO_3)_2$ solution are required to precipitate completely the sulphate ions in 25 mL of 0.80 M K_2SO_4 solution? **[50mL]**

8. What mass of silver chloride can be precipitated from a silver nitrate solution by 200 mL of a solution of 0.50 M $CaCl_2$? **[28.7g]**