Name _____ Period _____

Concentration Calculations Worksheet

Concentration units	How the units are calculated
molar (M) and millimolar (mM)	Divide moles of solute by volume of solution in liters. $M = \frac{\text{moles}}{\text{L}}$ mM = M x 1000
grams per liter (g/L)	Divide grams of solute by volume of solution in liters.
percent composition	Divide mass of solute by total mass of solution, multiply by 100 for percent. Percent composition is typically used for high concentration solutions. $\%\text{ composition} = \frac{\text{g solute}}{\text{g solution}} \times 100$
ppm = parts-per-million	Divide mass of solute by total mass of solution, multiply by 1,000,000 (10^6). Typically used for low concentration solutions such as pollutants in water. $\text{ppm} = \frac{\text{g solute}}{\text{g solution}} \times 10^6$ Also equal to mg/L for dilute solutions.

Examples

1. What is the molarity of 10.0 g of salt dissolved in water to make 100. mL?

$$10.0\text{ g NaCl} \times \frac{1\text{ mol NaCl}}{58.5\text{ g NaCl}} = 0.171\text{ mol NaCl} \qquad \frac{0.171\text{ mol NaCl}}{0.1\text{ L}} = 1.71\text{ M NaCl}$$

2. How many grams of glucose are in 50.0 mL of a 138 mM solution of glucose in water?

$$0.050\text{L} \times \frac{0.138\text{ mol glu}}{\text{L}} = 0.00690\text{ mol glu} \qquad 0.00690\text{ mol glu} \times \frac{180\text{ g glu}}{\text{mol glu}} = 1.24\text{ g glu}$$

or

$$0.050\text{L} \times \frac{0.138\text{ mol glu}}{\text{L}} \times \frac{180\text{ g glu}}{\text{mol glu}} = 1.24\text{ g glu}$$

3. How many grams of oil are in 500 g of a gasoline-oil mix that is 5% oil?

$$500\text{ g gasoline-oil} \times \frac{0.05\text{ g oil}}{\text{g gasoline-oil}} = 25\text{ g oil}$$

4. The EPA (Environmental Protection Agency) currently limits the concentration of fluoride in drinking water to no more than 4.0 mg per liter of water. What is this concentration in parts-per-million (ppm)?

$$\frac{4.0 \times 10^{-3}\text{ g } F^-}{\text{L water}} \times \frac{1\text{ L water}}{10^3\text{ g water}} \times 10^6 = 4.0\text{ ppm}$$

Problems

1. What is the molarity of the solution when 145 g NaCl is dissolved in water to make 2.75 L of solution?

2. How many grams of potassium chloride are needed to prepare 0.750 L of a 1.50 M solution of KCl in water?

3. What is the molarity of the solution produced when 85.6 g of hydrochloric acid (HCl) is dissolved in enough water to prepare 385 mL of solution?

4. To produce 4.00 L of a 250. mM solution of sodium hydroxide (NaOH), how many grams of NaOH must be dissolved?

5. If 8.77 g of potassium iodide (KI) are dissolved in sufficient water to make 4.75 L of solution, what is the molarity of the solution?

6. What is the concentration in mM of 4.80 g of citric acid ($C_6H_8O_7$) dissolved in water to make 1.00 L? (The molar mass of citric acid is 192 g/mole)

7. The concentration of sugar in a soft drink is measured to be 10.5%. How many grams of sugar are in 125 g of the drink?

8. The label on an Ocean Spray Cran-Raspberry drink lists 30 g of sugar in 240 mL of drink. I weighed 240 mL of drink and found its mass to be 251 g. What is the percent composition of sugar in the drink?

9. What is the concentration of sugar in Ocean Spray Cran-Rasberry juice in grams per liter?

10. A drinking water plant adds 500 grams of fluoride to a water tank containing 500,000 liters of drinking water. What is the concentration of fluoride in the water in parts-per-million (ppm)?

More Concentration Units

Concentration units	How the units are calculated
mole fraction (X)	Divide moles of component (solute or solvent) by *total* moles of solution $X_{solute} = \frac{\text{moles of solute}}{\text{moles of solution}}$
molal (m)	Divide moles of solute by mass of *solvent* (not solution) in kg $m = \frac{\text{moles (solute)}}{\text{kg (solvent)}}$

Examples

5. What are the mole fractions of glucose and water when 50.0 g glucose is dissolved in 100. g H_2O?

$$50.0 \text{ g glu} \times \frac{\text{mol glu}}{180. \text{ g glu}} = 0.278 \text{ mol glu} \qquad 100. \text{ g } H_2O \times \frac{1 \text{ mole } H_2O}{18.0 \text{ g } H_2O} = 5.56 \text{ mol } H_2O$$

$$0.278 \text{ mol glu} + 5.56 \text{ mol } H_2O = 5.84 \text{ mol total}$$

$$X_{glu} = \frac{0.278 \text{ mol glu}}{5.84 \text{ mol total}} = 0.0476 \qquad X_{water} = 1.0000 - 0.0476 = 0.9524$$

The sum of all the mole fractions is equal to 1.

6. What is the molality of 50.0 g of glucose dissolved in 100. g of water?

$$50.0 \text{ g glu} \times \frac{1 \text{ mol glu}}{180 \text{ g glu}} = 0.278 \text{ mol glu} \qquad \frac{0.278 \text{ mol glu}}{0.100 \text{ kg water}} = 2.78 \, m$$

Note that 2.78 *m* is a lower concentration than 2.78 M because addition of 50 g of glucose to 100 mL of water will cause the actual volume of the solution to be greater than 100 mL.

Problems

11. A bottle of rubbing alcohol contains 75% by mass 2-propanol (C_3H_8O) in water. What are the mole fractions of 2-propanol and water in the solutions?

12. What is the molality of the solution when 328 g NaCl is dissolved in 3.50 kg water?

13. How many grams of ethylene glycol ($C_2H_6O_2$) are needed to mix with 5.00 kg of water to prepare a 3.50 *m* solution?

14. 100.0 g of saltwater is weighed out and all of the water evaporated. The remaining salt is found to have a mass of 23.8 g. What was the molality of the original solution? (Hint: Be sure to check the definition of molality before doing this problem!)