Drug Dosage Calculations: Percent Solutions

MANY MEDS are pre-mixed and are ready to administer in single doses. But the majority of medications are not unit dose medications. Therefore, a health care professional must do the necessary math to alter the dose to fit the circumstance. Are your math skills up to the challenge?

Objectives:

1. Define terms related to percent solutions and drug dosage calculations.
2. Calculate weight/volume (W/V) percent solutions.
3. Calculate volume/volume (V/V) percent solutions.

Key Terms:

concentration
percent
percent solution
solute
solution
solvent
unit dose medications

FIGURE 1. Often liquid medicines, IV solutions, and IV additives must be mixed prior to administration.

Understanding Percent Solutions

Unit dose medications are pre-mixed, pre-packaged, and ready to administer single doses for a patient. Unit dose packaging reduces the risk of medication errors, but some

medications (e.g., liquid medicines, IV solutions, and IV additives) must be mixed prior to administration. Lab technicians, pharmacy technicians, pharmacists, nurses, and doctors must be able to perform the calculations necessary to prepare solutions and to determine the drug strength and the dosage of various liquid solutions.

Pretend you are making a cup of chocolate milk using a powdered chocolate mix and milk. How could you alter the strength of the chocolate milk? You could add more chocolate mix or use less milk. But what if you were making chocolate milk with liquid chocolate syrup and milk? How could you alter the strength of the chocolate milk?

Let's say that you make the best chocolate milk ever, and a friend wants to know how you do it. How could you express the strength of your chocolate milk solution in a mathematical formula? You may use a ratio or a proportion for the amount of chocolate powder/syrup to the total amount of milk. In health care, the strength of solutions and some medications are often expressed in a similar fashion.

TERMS RELATED TO PERCENT SOLUTIONS AND DRUG DOSAGE CALCULATIONS

Some key vocabulary terms are related to percent solutions. These terms are foundational for calculating percent solutions:

- **Solution** is a uniform or homogenous mixture of two or more substances. In the chocolate milk analogy, the final chocolate milk drink is a solution composed of the powdered chocolate milk mix or the syrup and the milk.
- **Solute** is the part of a solution that is dissolved in a liquid. It may be a solid or a liquid. In the chocolate milk analogy, the powdered chocolate mix is a solid solute, and the chocolate syrup is a liquid solute.

  If the solute is a solid, the solution concentration can be defined by the weight of the solute—typically expressed in grams—in relation to the volume of the solution. In the chocolate milk analogy, this is the grams of powdered chocolate milk mix in the total milliliters of finished chocolate milk drink.

  If the solute is a liquid, the solution concentration can be defined by the volume of the solute—typically expressed in milliliters (mL) or cubic centimeters (cc)—in relation to the volume of the solution. In the chocolate milk analogy, this would be the milliliters of chocolate syrup in the total milliliters of the chocolate milk drink.

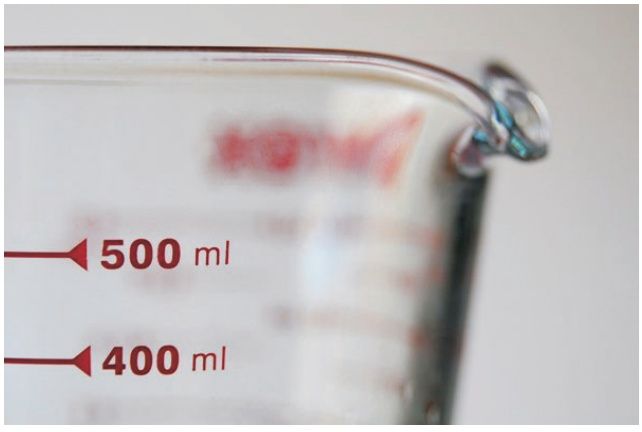

FIGURE 2. The volume of the solute is often expressed in milliliters.

- **Solvent** is the substance in which the solute is dissolved. In the chocolate milk analogy, the milk is the solvent.

- **Concentration** is the strength of a solution; it describes the amount of solute that is dissolved in a given quantity of solvent.
- **Percent** is a term that indicates "parts per 100."
- A **percent solution** is a mathematical expression of the concentration or strength of a solution that compares the solute to 100 mL of the total solution.

Weight/Volume Percent Solutions

W/V (weight/volume) percent solutions are also known as M/V (mass/volume) percent solutions. It compares a solid solute (measured in grams) to 100 mL of the total solution. To prepare a W/V percent solution, a solid solute (measured in grams) is added to a volume of solvent to reach a total volume of 100 mL of solution.

A one percent (W/V) solution is one gram of solute in a sufficient amount of solvent (e.g., water) to produce 100 mL of solution. A one percent solution is not one gram of solute in 100 mL of solvent; it is one gram of solute dissolved in enough solvent to make a total of 100 mL of solution. In the chocolate milk analogy, a five percent chocolate milk solution would be five grams of powdered chocolate milk mix combined with enough milk to make a total of 100 mL of chocolate milk drink. A seven percent saltwater solution is seven grams of salt dissolved in enough water to make 100 mL of solution.

Volume/Volume Percent Solutions

V/V (volume/volume) percent solutions compare a liquid solute (measured in milliliters) to 100 mL of the total solution. To prepare a V/V percent solution, a liquid solute (measured in milliliters) is added to a volume of solvent to reach a total volume of 100 mL of solution. A one percent (V/V) solution is one milliliter of solute in a sufficient amount of solvent (e.g., water) to produce 100 mL of solution. A one percent solution is not one mL of solute in 100 mL of solvent. It is one mL of solute in enough solvent to make a total of 100 mL of solution.

In the chocolate milk analogy, a five percent chocolate milk solution would be 5 mL of chocolate syrup combined with enough milk to make a total of 100 mL of chocolate milk drink. An alcoholic beverage that is seven percent alcohol contains 7 mL of alcohol per 100 mL of the beverage.

CALCULATE WEIGHT/VOLUME PERCENT SOLUTIONS

When preparing to perform weight/volume percent solution calculations, you must learn the following formula:

$$\text{M/V (mass/volume) percent solution} = \frac{\text{Mass of solute (g)}}{\text{Volume of solution (mL)}} \times 100$$

This formula can be interpreted as the mass/volume percent solution equals the mass of the solute (g) divided by the volume of the solution (mL) multiplied by 100.

Observe how the formula (and proportions) is used to solve the following problems and to calculate drug dosages.

FURTHER EXPLORATION...

ONLINE CONNECTION: Practice with Percent Solutions

Apply your new knowledge of proportions and the use of formulas for weight/volume percent solutions and volume/volume percent solutions. Show your work. Be sure your answers include the correct unit of measure. Once you have completed the problems, use the online sites to check your work.

Formula for Weight/Volume Percent Solutions:

$$\text{M/V (mass/volume) percent solution} = \frac{\text{Mass of solute (g)}}{\text{Volume of solution (mL)}} \times 100$$

Formula for Volume/Volume Percent Solutions:

$$\text{V/V (volume/volume) percent solution} = \frac{\text{volume of solute (mL)}}{\text{volume of solution (mL)}} \times 100$$

Problems Relating to Weight/Volume Percent Solutions

1. What is the percent concentration of a solution that you make by diluting 40 g of CaCl2 in enough water to make 500 mL of solution?
2. If you have 4.8 g of NaCl dissolved in 82 mL of solution, what is the percent of the solution?
3. How much salt is needed to make 1,000 mL of a 20 percent solution?
4. How would you make 250 mL of an 8.5 percent NaCl solution?
5. How would you prepare 200 mL of a 15 percent salt in water solution?
6. How many grams of sodium bicarbonate are there in 52 mL of a 6.3 percent solution?
7. 10.3 grams of NaCl are dissolved and diluted in a solvent to make a total of 250 mL of solution. What is the percent concentration?
8. How many grams of the powdered antibiotic An-Biot would be needed to prepare a 250 mL of a 20 percent solution of antibiotic and water?

Problems Relating to Volume/Volume Percent Solutions

1. What is the percent concentration of a solution that contains 65 mL of NuPanol in 250 mL of solution?
2. Suppose you have 9 mL of alcohol in 25 mL of solution. Express this as a (V/V) percent solution.
3. How would you make 500 mL of 30 percent vinegar in water solution?

4. How many milliliters of bleach would you need to prepare a 100 mL of a 10 percent bleach solution?
5. A 320-mL bottle of solution is labeled as a 7.5 percent bleach solution. How many mL of bleach are there in the solution?
6. How many milliliters (mL) of phenol are needed to prepare 250 mL of a 3 percent solution?
7. How many milliliters of a drug are needed to make 1,000 mL of a 25 percent solution?
8. You are making an IV additive. How many milliliters of the drug are needed to prepare 50 mL of a 40 percent solution?

Check your work with this website: http://www.algebrahelp.com/calculators/equation/proportions/. The correct answer will depend on you setting up your problems correctly. Pay attention to the key terms and the units of measure.

- For example, if you have 80 g of sodium chloride (NaCl) in 250 mL of water, it can be expressed as a (W/V) percent solution.

  Answer: (W/V) percent solution $= \frac{80\text{ g}}{250\text{ mL}} \times 100$. Therefore (W/V) percent solution = 0.32 × 100 and (W/V) percent solution = 32 percent. So the 80 g of NaCl in 250 mL of water is a 32 percent solution.

- How many grams of sugar are needed to make 150 mL of a 30 percent solution? Set up a proportion. Remember that a 30 percent solution is equivalent to 30 grams of sugar in 100 mL of solution.

  $\frac{30\text{ g}}{100\text{ mL}} = \frac{x}{150\text{ mL}}$, so 100x = 4,500. Therefore, $\frac{100x}{100} = \frac{4500}{1100}$, and x = 45 g.

  Answer: 45 grams of sugar are needed to make 150 mL of a 30 percent solution.

CALCULATE VOLUME/VOLUME PERCENT SOLUTIONS

When preparing to perform volume/volume percent solution calculations, you must learn the following formula:

$$\text{V/V (volume/volume) percent solution} = \frac{\text{volume of solute (mL)}}{\text{volume of solution (mL)}} \times 100$$

This formula can be interpreted as the volume/volume percent solution equals the volume of solute (mL) divided by the volume of solution (mL) multiplied by 100.

Observe how the formula (and proportions) is used to solve the following problems and to calculate drug dosages.

- You have 50 mL of a liquid drug dissolved in 250 mL of solution. Express this as a V/V percent solution. (Answer: V/V (volume/volume) percent solution $= \frac{50 \text{ mL}}{250 \text{ mL}} \times 100$, so V/V (volume/volume) percent solution $= 0.2 \times 100$. As a result, V/V (volume/volume) percent solution = 20 percent.
- How would you make 500 mL of 30 percent vinegar in water a solution? (Answer: Set up a proportion comparing this 30 percent vinegar in water solution, which is 30 mL of vinegar in 100 mL of total solution—with the 500 mL of total solution that you want to prepare, with "x" being the unknown amount of milliliters needed to prepare the 500 mL solution. Then solve for "x."

  $\frac{30}{100} = \frac{x}{500}$, so $100x = 15{,}000$. Therefore, $\frac{100x}{100} = \frac{15000}{100}$, and $x = 150$.

  To make 500 mL of 30 percent vinegar in water a solution, you would need 150 mL of vinegar added to water to make a total of 500 mL of solution.

Summary:

Health care professionals must be able to perform the calculations necessary to prepare solutions and to determine the drug strength and the dosage of various liquid solutions. Some key vocabulary terms are related to percent solutions. These terms are foundational for calculating percent solutions: solution, solute, solvent, concentration, percent, and percent solution.

When preparing to perform weight/volume percent solution calculations, you must learn the formula:

$$\text{M/V (mass/volume) percent solution} = \frac{\text{Mass of solute (g)}}{\text{Volume of solution (mL)}} \times 100$$

This formula can be interpreted as the mass/volume percent solution equals the mass of the solute (g) divided by the volume of the solution (mL) multiplied by 100.

W/V (weight/volume) percent solutions are also known as M/V (mass/volume) percent solutions. The formula compares a solid solute (measured in grams) to 100 mL of the total solution. To prepare a W/V percent solution, a solid solute (measured in grams) is added to a volume of solvent to reach a total volume of 100 mL of solution.

When preparing to perform volume/volume percent solution calculations, you must learn the formula:

$$\text{V/V (volume/volume) percent solution} = \frac{\text{volume of solute (mL)}}{\text{volume of solution (mL)}} \times 100$$

This formula can be interpreted as the volume/volume percent solution equals the volume of solute (mL) divided by the volume of solution (mL) multiplied by 100.

V/V (volume/volume) percent solutions compare a liquid solute (measured in milliliters) to 100 mL of the total solution. To prepare a V/V percent solution, a liquid solute (measured in milliliters) is added to a volume of solvent to reach a total volume of 100 mL of solution. A one percent (V/V) solution is one milliliter of solute in a sufficient amount of solvent (e.g., water) to produce 100 mL of solution.

Checking Your Knowledge:

1. How many grams of salt are in a 4 percent saltwater solution? Show your calculations.
2. How many milliliters of glycol are in 100 mL of a 95 percent glycol and water solution? Show your calculations.
3. How many grams of a drug are needed to make 50 mL of a 30 percent solution? Show your calculations.
4. Define "percent solution."
5. In the chocolate milk solution analogy, the milk in which the powder or the syrup dissolves is what?

Expanding Your Knowledge:

Create your own lab. Prepare nine small glasses of chocolate milk. Make the first glass a 10 percent solution and the next a 20 percent solution. Continue to strengthen the solutions till you reach 90 percent. Which do you think is the best?

Web Links:

Volume/Volume Percentages
http://www.chembuddy.com/?left=concentration&right=volume-volume-percentage

Mass/Volume Percentages
http://www.chembuddy.com/?left=concentration&right=mass-volume-percentage

Algebra Help
http://www.algebrahelp.com/calculators/equation/proportions/

Ratios and Proportions
http://www.shodor.org/UNChem/math/r_p/index.html