MODULE 4

CALCULATIONS INVOLVING SOLUTIONS

Calculations Involving Solutions Module

OBJECTIVES:

1. Given a solution whose strength is expressed in percentage strength, state the number of grams of chemical substance contained in 100 milliliters of that solution.

2. Given a solution whose strength is expressed in ratio strength, state the volume of drug solution that contains 1 gram of chemical solution.

3. Given a drug solution expressed in terms of percentage strength, ratio strength, or direct statement strength (mg/ml, g/ml, etc.) calculate the volume of that solution required to deliver a stated amount of that drug.

4. Given an order calling for a stated volume of a specified percentage or ratio strength solution, calculate the amount of drug needed to prepare that solution.

Many of the medications in which you will be working are supplied in the form of solutions. Therefore, individuals who are responsible for the preparation of sterile products must have the ability to work with solutions which have their concentrations expressed in a variety of ways. To aid you in working with solutions, this module will review the concept of solutions and discuss calculations involving percentage strength, ratio strength, and direct statement strength expressions.

A solution is always composed of two parts--the solute and the solvent.

SOLUTE + SOLVENT = SOLUTION
(A) + (B) = (C)

The SOLUTE is the substance which is DISSOLVED in the solvent. In most cases, the solute is present in a lower proportion in the solution. An example of a solute is dextrose. The solvent is usually present in the higher proportion. The solvent is usually present in the higher proportion. The SOLVENT is the substance in which the solute is dissolved. An excellent example of a solvent is water.

SOLUTE + SOLVENT = SOLUTION

--OR--

Dextrose + Water = Dextrose Solution

Therefore, when dextrose is dissolved in water, dextrose solution is prepared.

Two parts are necessary to prepare a solution. Name these two parts:

1.

2.

ANSWER: 1. Solute (any order)
2. Solvent

If 5 grams of sodium chloride were added to 500 milliliters of water, a solution would be prepared. In this instance, the sodium chloride would be referred to as the while the water would be called the

ANSWER: Sodium chloride would be the solute, while the water would be the solvent.

An extremely important concept to understand about solutions is the fact that the particles of the solute are equally distributed among the particles of the solvent. In other words, in a 1,000 milliliter sample of dextrose solution, each 1 milliliter of the solution would contain the same amount of dextrose (solute).

As a person who works with IV Medication Preparation, one needs to be familiar with the addition of a prescribed amount of a drug to the intravenous solution. In most cases the drugs which you will be working with, will be in the form of a solution. Therefore, you must be able to take a drug in solution--regardless of how the strength or concentration of that solution is expressed--and calculate what volume of that solution is required to supply the needed amount of the drug.

Earlier in a module dealing with ratio and proportion principles it was shown that these principles could be used to help one solve pharmaceutical calculations both quickly and accurately. These same ratio and proportion principles can be used to solve problems dealing with solutions--regardless of how a solution's concentration is expressed.

It is imperative that you be able to work with solutions whose strengths are expressed in a variety of ways. once you are able to state precisely the amount of a drug contained in a specified volume of solution, then you are well on your way to be able to perform many pharmaceutical calculations both quickly and accurately.

We rely primarily on three ways of expressing the amount of a drug which is contained in a given volume of solution. These three methods used in the expression of the concentration of drugs in solution are referred to as DIRECT STATEMENT, PERCENTAGE STRENGTH, and RATIO STRENGTH.

The first method, DIRECT STATEMENT, is the method used to express the strength of most drugs which are in solution form. with DIRECT STATEMENT, the amount of drug per given volume of solution is stated on the label of the drug container in direct terms. The direct statement form uses ratios to express concentration. Below are some examples of drugs in solution whose strength are expressed in DIRECT STATEMENT form.

Meperidine (Demerol)	50 mg per ml
Potassium Chloride solution	2 mEq per ml

NOTE: At present, you are not expected to be familiar with the term "milliequivalent" (mEq).

Kanamycin Sulfate Injection (Kantrex) 1 gram per 3 ml

Therefore, meperidine (Demerol) injection, 50 mg per ml contains 50 milligrams of meperidine in each milliliter of the solution. Potassium chloride solution, 2 mEq per ml, contains 2 milliequivalents of potassium chloride in each milliliter of the solution. Kanamycin Sulfate Injection (Kantrex), 1 gram per 3 ml, contains 1 gram of kanamycin sulfate in each 3 milliliters of the solution.

Below are examples of other solutions which are expressed in terms of direct statement concentration:

Sodium chloride solution, 2.5 milliequivalents/ml.

Aminophylline solution, 25 mg/ml

Answer the following questions:

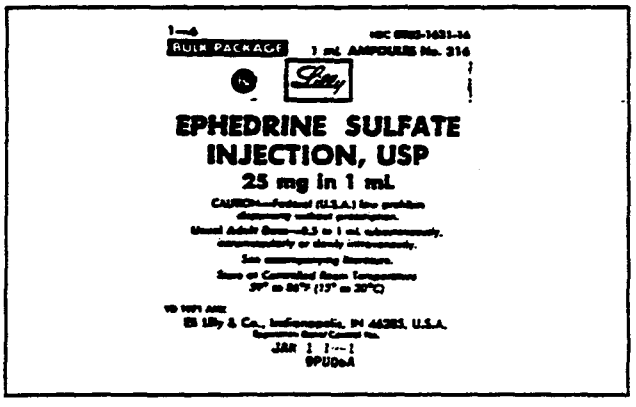
Each ml of the sodium chloride solution contains_____of sodium chloride.

Each ml of the aminophylline solution contains_____ of aminophylline.

ANSWER:
Each ml of the sodium chloride solution contains 2.5 milliequivalents of sodium chloride.

Each ml of the aminophylline solution contains 25 mg of aminophylline.

Below is the cover from a box of 6 ampules of Ephedrine Sulfate Injection, U.S.P. Each ampule of the medication contains 1 milliliter of the drug solution.



Each ml of the Ephedrine Sulfate Injection, U.S.P. contains_____ of the drug.

ANSWER: Each ml of the Ephedrine Sulfate Injection, U.S.P. contains 25 mg of the drug.

In other cases, drug strengths are listed in terms of percentage strength and ratio strength. In the nursing section, many drugs have their concentrations expressed in percentage form. Examples of drugs which are expressed in percentage form are Dextrose 5% in Water and 0.9% Sodium Chloride Injection. In each case above, the percent sign (%) is easily seen. This percent sign (%) means parts per 100 parts. Thus, 5% indicates 5 parts per 100 parts or

$$5\% \quad \frac{5 \text{ parts}}{100 \text{ parts}}$$

In other words, there are 5 parts of solute (drug) dissolved in 100 parts of solution (solvent PLUS solute).

Here is a common example: Dextrose 5% in Water

$$\text{Dextrose 5\% in Water} = \frac{\text{5 parts of Dextrose (drug)}}{\text{100 parts of solution (drug plus solvent)}}$$

In dosage calculations, these "parts" must be expressed in metric units. Therefore, the calculation on the previous page becomes:

$$\text{Dextrose 5\% in Water} = \frac{\text{5 GRAMS of Dextrose (Weight)}}{\text{100 MILLILITERS of solution (Volume)}}$$

Saying it another way, a 100 milliliter bottle filled with Dextrose 5% in Water would contain 5 grams of dextrose.

NOTE: All percentage strength solutions should be expressed as "X" grams of drug per 100 milliliters of solution.

Here is another example: 15% Mannitol Injection

15% Mannitol Injection = $\frac{\text{15 parts of Mannitol}}{\text{100 parts of solution}}$ =

$\frac{\text{15 parts of Mannitol}}{\text{100 parts of solution}}$ = $\frac{\text{15 GRAMS of Mannitol}}{\text{100 MILLILITERS of solution}}$

Fill in the required information:

$\frac{\text{10 parts of Dextrose}}{\text{100 parts of solution}}$ = $\frac{\text{"X"}}{\text{100 MILLILITERS of solution}}$

ANSWER: Dextrose 10% Solution= $\frac{\text{10 GRAMS of Dextrose}}{\text{100 MILLILITERS of solution}}$

Express the following percents as ratio fractions:

1. 15% = $\frac{a}{100}$

2. 70% = $\frac{b}{100}$

3. 0.25% = $\frac{c}{100}$

4. 1/2% = $\frac{d}{100}$

ANSWERS: a=15, b=70, c=0.25, d=1/2

Express the following percents as the number of grams of solute (drug) per 100 milliliters of solution.

75% = ___?___ grams of drug per 100 milliliters of solution

ANSWER: 75% = 75 grams of drug per 100 milliliters of solution.

10% = ___X___ grams of drug per 100 milliliters of solution.

0.1% = ___X___ grams of drug per 100 milliliters of solution.

0.75% = ___X___ grams of drug per 100 milliliters of solution.

ANSWERS : 10 grams, 0.1 grams,
75 grams respectfully

It has been stated that percent means the number of grams of solute (drug) that is contained in 100 milliliters of solution. Using the concept of percent and the principles of ratio and proportion, solve the following problem:

You have an order calling for a particular drug to be added to a liter of Dextrose 5% in Water. How many grams of dextrose are contained in the liter container of the dextrose solution?

ANSWER: Basically the question is: "How many grams of dextrose are contained in a liter (1 liter = 1000 ml) of Dextrose 5% in Water?"

$$5\% = \frac{\text{5 grams of dextrose}}{\text{100 milliliters of solution}}$$

$$\text{IF } \frac{\text{5 grams of dextrose}}{\text{100 milliliters of solution}} = \text{THEN } \frac{\text{"X" grams of dextrose}}{\text{1000 milliliters of solution}}$$

$$(100)(\text{"X"}) = (5)(1000)$$
$$100X = 5000$$

X = 50 grams of dextrose in 1000 milliliters of solution

0.9% Sodium Chloride Solution contains _____gm of sodium chloride in 100 milliliters of solution.

ANSWER: 0.9% Sodium Chloride Solution contains 0.9 gram of sodium chloride in 100 milliliters of solution.

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500 milliliters of 0.9% Sodium Chloride Solution contains _____grams of sodium chloride.

ANSWER: 0.9% = 0.9 gram of sodium chloride per 100 milliliters of solution

$$\text{IF } \frac{\text{0.9 gram}}{\text{100 milliliters}} = \text{THEN } \frac{\text{"X" grams}}{\text{500 milliliters}}$$

$(100)(X) = (0.9)(500)$

$100X = 450$

$X = 4.5$ grams of sodium chloride per 500 milliliters of soln

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In order to simplify the expression of percents, one can apply his knowledge of the metric system. Below is an example of the simplification of percent.

$$5\% = \frac{\text{5 grams of drug}}{\text{100 milliliters of solution}}$$

REMEMBER: I gram = 1,000 milligrams

Since 5 grams = 5000 milligrams, then

$$5\% = \frac{\text{5 grams of drug}}{\text{100 milliliters of solution}} = \frac{\text{5000 milligrams of drug}}{\text{100 milliliters of solution}}$$

Then the zeros can be reduced,

$$\frac{\text{5000 milligrams of drug}}{\text{100 milliliters of solution}} = \frac{\text{50 milligrams of drug}}{\text{1 milliliter of solution}}$$

Express the following percents as milligrams of drug per milliliter of solution.

$$5\% = \frac{\text{5 grams}}{\text{100 milliliters}} = \frac{\text{X mg}}{\text{1ml}}$$

ANSWER: $5\% = \frac{\text{5 grams}}{\text{100 milliliter}} = \frac{\text{5000 milligrams}}{\text{100 milliliters}} = \frac{\text{50 milligrams}}{\text{1 milliliter}}$

12% = X mg/ml

ANSWER: 12% = $\frac{12 \text{ grams}}{100 \text{ milliliters}} = \frac{1200 \text{ milligrams}}{100 \text{ milliliters}} = \frac{120 \text{ milligrams}}{1 \text{ milliliter}}$

0.5% = X mg/ml

ANSWER: 0.5% = $\frac{0.5 \text{ gram}}{100 \text{ milliliters}} = \frac{500 \text{ milligrams}}{100 \text{ milliliters}} = \frac{5 \text{ milligrams}}{1 \text{ milliliter}}$

Up to now, topics such as DIRECT STATEMENT of strength and PERCENTAGE strength have been discussed. Most of the stocked drugs have their strengths expressed in one of these means. However, in some cases, drugs which have their strength expressed in RATIO STRENGTH will be encountered. A common example of a medication whose strength is expressed in RATIO STRENGTH is epinephrine. Epinephrine with a strength of 1:1000 is frequently seen in every hospital in the country.

RATIO STRENGTH is just another way of writing a fraction. For example, with Epinephrine, 1:1000, the 1:1000 could be written as $\frac{1}{1000}$.

As with percentage strength, ratio strength can be introduced with the following statement:

1:1000 = $\frac{1}{1000}$ = $\frac{1 \text{ part of epinephrine}}{1000 \text{ parts of solution (solvent plus drug)}}$

NOTE: Ratio Strengths are almost always used to express the strength of solutions whose percentage strengths would be less than 1%.

As with percentage strength solutions, these "parts" must be expressed in units of the metric system before any calculations can be performed.

Therefore,

$$1{:}1000 \quad \frac{\text{1 part of drug}}{\text{1000 parts of solution}} = \frac{\text{1 Gram of drug}}{\text{1000 milliliters of solution}}$$

Isoproterenol solution, 1:2000

$$1{:}2000 = \frac{\text{1 part of drug}}{\text{2000 parts of solution}} = \frac{\text{1 Gram of drug}}{\text{2000 milliliters of solution}}$$

Notice that in RATIO STRENGTH solutions, there is always 1 gram of the drug per "X" cc of solution. Thus, 1:5 would mean there is I gram of drug per 5 cc of solution.

Fill in the blank with the appropriate information:

a. 1:1000 =_____

b. 1:750 =_____

c. 1:1500 =_____

ANSWERS:
a. 1 gram of drug per 1000 milliliters of solution.
b. 1 gram of drug per 750 milliliters of solution.
c. 1 gram of drug per 1500 milliliters of solution.

Of the list of RATIO STRENGTHS listed below, select the most concentrated solution: (Circle your response)

1:50,000
1:5,000
1:200
1:2,000
1:400,000

ANSWER: 1:200 = 1 gram of drug per 200 milliliters of solution. Therefore, *1:200 would be the most concentrated of the solutions listed above.*

As with percentage strengths, ratio strength solutions can be stated in expressions in milligrams per milliliter (mg/ml). In many cases, this simplification into milligrams per milliliter can make RATIO STRENGTH solutions *easier to calculate. This simplification can be performed as follows.*

Example: Epinephrine solution, 1:1000

$$1{:}1000 = \frac{1 \text{ gram of epinephrine}}{1000 \text{ milliliters of solution}}$$

$$= \frac{1000 \text{ milligrams of epinephrine}}{1000 \text{ milliliters of solution}}$$

$$= \frac{1 \text{ milligram of epinephrine}}{1 \text{ milliliter of solution}}$$

Isoproterenol solution, 1:500, has_____mg of the drug per milliliter of solution.

ANSWER: $1:500 = \frac{1 \text{ gram}}{500 \text{ milliliters}} = \frac{1000 \text{ milligrams}}{500 \text{ milliliters}} = \frac{10 \text{ milligrams}}{5 \text{ milliliter}}$

$= \frac{2 \text{ milligrams of the drug}}{1 \text{ milliliter of solution}}$

You have now been exposed to several methods of expressing the strength of solutions. In particular, concepts involving PERCENTAGE STRENGTH and RATIO STRENGTH were stressed. For the remainder of this module you can use these concepts to help you solve the following problems.

Levarterenol Bitartrate Injection comes supplied in 4 milliliter ampules labeled 0.2%. How many milligrams of the drug are contained in each ampule?

ANSWER: $0.2\% = \frac{0.2 \text{ grams}}{100 \text{ milliliters}} = \frac{200 \text{ milligrams}}{100 \text{ milliliters}} = \frac{2 \text{ milligrams}}{1 \text{ milliliters}}$

IF $\frac{2 \text{ milligrams}}{1 \text{ milliliter}}$ THEN $\frac{X \text{ milligrams}}{4 \text{ milliliters}}$

$(1)(X) = (2)(4)$

$X = 8$ milligrams per 4 milliliter ampule

You are working with an EVAC Hospital in South America. Your Position is suddenly attacked by a tribe of lost Indians using Curare-tipped arrows. One of the medics is hit and you receive a STAT order for 1.25 milligrams of Neostigmine methyl sulfate (the antidote). You find the neostigmine in ampules labeled 1:4000. How many cc of this solution must be used to administer the desired dose?

ANSWER: $1{:}4000 = \frac{1 \text{ gram}}{4000 \text{ cc}} = \frac{1000 \text{ mg}}{4000 \text{ cc}} = \frac{1 \text{ mg}}{4 \text{ cc}}$

The solution contains 1 mg of the drug in each 4 cc of the solution.

IF $\frac{1 \text{ mg}}{4 \text{ cc}}$ THEN $\frac{1.25 \text{ mg}}{X \text{ cc}}$

$(1)(X) = (4)(1.25)$

$X = 5$ cc of neostigmine

A patient is administered 0.5 cc of a 1:1000 Epinephrine solution. How many milligrams of epinephrine did the patient receive?

ANSWER: $1:1000 = \frac{1 \text{ gram}}{1000 \text{ ml}} = \frac{1000 \text{ mg}}{1000 \text{ ml}} = \frac{1 \text{ mg of epinephrine}}{1 \text{ ml of solution}}$

Thus, the solution contains I mg of epinephrine per 1 ml of solution.
The patient received 0.5 ml of the solution.

IF $\frac{1 \text{ mg}}{1 \text{ ml}}$ THEN $\frac{X \text{ mg}}{0.5 \text{ ml}}$

$$(1)(X) = (1)(0.5)$$

$$X = 0.5 \text{ mg of epinephrine received}$$

You wish to administer 50 mg of Aramine to a patient, and you are supplied with a 1% Aramine Injection. How many ccs of the 1% solution would you need for 50 mg of Aramine?

ANSWER: $1\% = \frac{1\text{ gm}}{100\text{ ml}} = \frac{1000\text{ mg}}{100\text{ ml}} = \frac{10\text{ mg of Aramine}}{1\text{ ml of solution}}$

Thus, 10 mg of Aramine are contained in each 1 ml of the solution.

IF $\frac{10\text{ mg}}{1\text{ ml}}$ THEN $\frac{50\text{ mg}}{X\text{ ml}}$

$(10)(X) = (50)(1)$

$X = \frac{50}{10}$

X = 5 cc of the solution will supply 50 mg of Aramine

You have an order calling for a liter of 9% Dextrose Solution. In supply, you have a 500 cc bottle of Dextrose 50% and a 1000 cc bottle of Sterile Water for Injection. How many cc's of each solution must be used to prepare the order?

ANSWER:

(1) Determine the amount of dextrose which must be present in a liter (1000 ml) of 9% Dextrose solution.

$$9\% = \frac{9 \text{ gm}}{100 \text{ ml}}$$

IF $\frac{9 \text{ gm}}{100 \text{ ml}}$ THEN $\frac{X}{1000 \text{ ml}}$

X = 90 gm of dextrose would be present in a liter of 9% dextrose solution

(2) Determine the volume of Dextrose 50% in water which would provide 90 grams of dextrose.

Dextrose 50% in Water 50 grams of dextrose per 100 milliliters

IF $\frac{50 \text{ gm}}{100 \text{ ml}}$ THEN $\frac{90 \text{ gm}}{X \text{ ml}}$

X = 180 ml of Dextrose 50% solution

(3) Determine the volume of Sterile Water for Injection to use.

1000 ml = total volume of solution
-180 ml = volume of D50W which will be used
820 ml = volume of SWFI which must be used

During intracranial surgery you want to give 12.5 grams of mannitol. In stock, you find a 50 ml ampule of mannitol Injection labeled 25%. How many ml of the stock solution will be given?

ANSWER: 25% Mannitol Injection contains 25 grams of mannitol in 100 milliliters of solution.

$$\text{IF } \frac{25 \text{ gm}}{100 \text{ ml}} \quad \text{THEN} \quad \frac{12.5 \text{ gm}}{X \text{ ml}}$$

$$(25)(X) = (12.5)(100)$$

$$25X = 1250$$

X = 50 ml of the 25% solution would supply 12.5 grams of the drug.