PHARMACEUTICAL CALCULATIONS

6F-66F

U.S. ARMY GRADUATE PROGRAM
IN ANESTHESIA NURSING

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STANDARD SHEET

This Standard Sheet is provided to you in order that you may gain some insight into the standards required for acceptable performance on the calculations modules and practical exercise. Your work will be closely evaluated to ensure the following three elements are present:

1. The work is set up for each problem
2. Each number is labeled with the appropriate unit of measurement
3. Each problem is answered with the correct response

Illustrated below is a problem which serves as a model for you to follow in performing your calculations.

A patient is to be administered a dose of 200 milligrams of a drug. The drug is provided in the following concentration: 50 milligrams per milliliter of solution. Calculate the volume of the solution required to supply the 200 milligrams of medication.

$$\frac{50 \text{ mg}}{1 \text{ ml}} = \frac{200 \text{ mg}}{\text{“x” ml}}$$

$$50x = 200$$

$$x = 4 \text{ ml}$$

ANSWER:____4____milliliter(s)

MODULE 1

RATIO AND PROPORTION PRINCIPLES

RATIO AND PROPORTION PRINCIPLES

OBJECTIVE: Given a sterile product order form stating the amount of drug the patient is to be administered and the concentration of the drug expressed in milligrams per milliliter, milliequivalents per milliliter, grams per milliliter, or units per milliliter, calculate the volume of drug solution required to supply the needed amount of drug.

The principles of ratio and proportion are tools which allow you to solve the vast majority of pharmaceutical calculations. A thorough understanding of the concepts discussed in this module will enable you to deal with rather long and complicated calculations in a logical manner. Patiently work through each problem that is presented. Ensure that each ratio statement is properly set up and labeled. BE CAREFUL!!! Errors in division or multiplication can spell danger for patients.

EXPRESSING RATIOS:

You have surely heard of the term "ratio". One question frequently asked about a college is the ratio of male to female students. If there are six female students for every male student, then the males would view the ratio as very favorable. However, the female students would probably not look upon this ratio as very favorable because there are six female students to every one male student on the campus.

Basically, a ratio is the relationship between like numbers or values, or a ratio is a way to express a fractional part of a whole. Ratios may be written in a number of ways. For example:

as a fraction:	$\frac{2}{3}$	(Read as 2 parts of 3 parts)
as a division problem	$2 \div 3$	(Read as 2 divided by 3 or 3/2)
with the ratio or colon sign:	2:3	(Read 2 is to 3)
using "per":	50 miles per hour - or- 34 miles per gallon	

Therefore, one can see that ratios are commonly seen in everyday life. Ratios are also see whenever the strength or concentration of a form of medication is expressed. When one seeks to find the strength or concentration of a particular solution, one must read the label on the drug's container. This strength of the solution is really the ratio of the amount of drug to the volume of solution. For example:

Metaraminol Injection, 10 mg per cc (10 mg of metaraminol are contained in every 1.0 cc of the solution)	or	$\frac{10\ \text{mg}}{1\ \text{cc}}$
Tubocurarine Injection, 3 mg per cc (3 mg of the drug are contained in each 1.0 cc of the solution)	or	$\frac{3\ \text{mg}}{1\ \text{cc}}$
Morphine Injection, 15 mg per cc (15 mg of the drug would be contained in each 1.0 cc of the solution)	or	$\frac{15\ \text{mg}}{1\ \text{cc}}$
Potassium Chloride Solution (2 mEq of Potassium Chloride would be contained in each 1.0 cc of the solution)	or	$\frac{2\ \text{mEq}}{1\ \text{cc}}$

Using the package insert below, express the amount of calcium chloride present in 10 cc of the solution.

Sterile Solution

Calcium Chloride, 10% w/v

For Intravenous Use Only

Each 10 cc. ampoule contains 1 Gm. calcium chloride in water for injection q.s. When necessary, pH was adjusted with calcium hydroxide and/or hydrochloric acid.

_________gm of calcium chloride per____________cc of solution

ANSWER: 1 gram of calcium chloride per 10 cc of solution

PROPORTIONS

A proportion consists of two equal ratios and is a statement of equality between two ratios.

For example:

$$\frac{2}{5} = \frac{4}{10}$$

Observe that both fractions are really ratios. In this proportion we are saying that the ratio of 2 to 5 is the same as the ratio of 4 to 10.

A proportion may be written in either one of two ways. First of all, a proportion may be written utilizing the double colon (the proportion sign) ::.

MEANS

2 : 5 :: 4 : 10

EXTREMES

READ AS: 2 is to 5 as 4 is to 10

Secondly, a proportion may be written utilizing the sign of equality (=).

$$\frac{\text{(extreme) } 2}{\text{(mean) } 5} = \frac{4 \text{ (mean)}}{10 \text{ (extreme)}}$$

As can be seen, a proportion consists of four members. The middle two numbers are referred to as the means, while the two end numbers are called the extremes.

RULE: In a proportion, the multiplication product of the means is always equal to the multiplication product of the extremes. In other words:

mean times mean is equal to extreme times extreme, SO ...

$$\frac{2\text{ (extreme)}}{5\text{ (mean)}} = \frac{4\text{ (mean)}}{10\text{ (extreme)}}$$

$$2 \text{ times } 10 = 5 \text{ times } 4$$

$$20 = 20$$

NOTE: This rule always holds true in any proportion. If it does not, then a true equality does not exist.

QUESTION: Are the two ratios below proportional?

$$\frac{3}{12} = \frac{6}{24}$$

CIRCLE ONE: YES NO

EXPLAIN YOUR ANSWER:

ANSWER:
The two ratios are proportional

Solution: 3 times 24 = 6 times 12
72 = 72

Therrefore, the two ratios are proportional

SOLVING PROBLEMS WITH PROPORTIONS

Earlier it has been shown that the strength or concentration (the amount of drug contained in a given volume of solution) can be expressed as a ratio. It has also been shown that two equal ratios are proportional. Since the strength of drugs can be expressed as a ratio, we can use the principles of ratio and proportion to help us solve many pharmaceutical calculations.

Usually three knowns and one unknown exist in a Pharmaceutical calculations problem. Using the rule of proportions (the multiplication product of the extremes is always equal to the multiplication product of the means) and knowing the value of any three parts of the proportion, then the fourth unknown part (we will call this unknown part "X") can be found by using the following steps:

STEP 1: State the problem in "IF-THEN" form

STEP 2: Convert the problem to an equation

a. Known information (the labeled strength) should be your IF ratio

b. The unknown ratio including "X" will be your THEN ratio

c. Put like units on the same side of each ratio.

STEP 3: Cross multiply (mean times mean = extreme times extreme)

STEP 4: Solve for "X".

Using the steps above and the principles of ratio and proportion, solve the following problem:

The concentration of a particular drug solution is 2 milligrams per 1 cc. How many cc of the solution must be administered to a patient in order to give a dose of 10 milligrains of the drug?

Solution:

STEP 1: State the problem in "IF-THEN" form

IF there are 2 milligrams of the drug in each cc of the solution,

THEN there would be 10 milligrains of the drug in "X" cc of the solution.

STEP 2: Convert the problem to an equation.

a. Known information (the drug's strength) should be your IF ratio.

$$\text{IF} \qquad \frac{2 \text{ mg}}{1 \text{ cc}}$$

b. The unknown ratio including "X" will be your THEN ratio

$$\text{THEN} \qquad \frac{10 \text{ MG}}{\text{"X" cc}}$$

c. Put like units on the same side of each ratio and set the two ratios equal to each other

$$\text{IF} \quad \frac{2\text{ mg}}{1\text{ cc}} = \text{THEN} \quad \frac{10\text{ mg}}{\text{“x” cc}}$$

STEP 3: Cross multiply (mean times mean = extreme times extreme)

2 mg times "X" cc = 1 cc times 10 mg

STEP 4: Solve for “x”

$$\text{“x” cc} = \frac{(1\text{ cc})(10\text{ mg})}{2\text{ mg}}$$

After canceling units, $\text{"x" cc} = \frac{(1\text{ cc})\ (10)}{2}$

$$\text{“x” cc} = \frac{10}{2}$$

$$\text{“x” cc} = 5$$

“x” cc = 5 cc of the solution

Therefore, 5 cc of the drug solution would contain 10 milligrams of the drug.

SOLVE THE FOLLOWING PROBLEM USING RATIO-PROPORTION PRINCIPLES

A syringe order calls for 7.5 mg of Compazine and in supply you find an ampule of Compazine labeled "10 mg per 2 cell. How many cc of the solution must be drawn up into a syringe in order to supply the needed dose of the drug?

STEP 1: State the problem in "IF-THEN" form

ANSWER:

IF there are 10 mg of the drug in each 2cc of the solution.

THEN there would be 7.5 mg of the drug in

STEP 2: Convert the problem to an equation

a. The known information (the drug's labeled strength) should be your IF ratio

IF $\frac{\_\_\_\text{ mg}}{\text{cc}}$

ANSWER:

IF $\frac{10\text{ mg}}{2\text{ cc}}$

b. The unknown ratio, including "x" will be your THEN ratio

THEN $\frac{\_\_\_\_\text{ mg}}{\text{cc}}$

ANSWER:

THEN $\frac{7.5\text{ mg}}{\text{“x” cc}}$

C. Put like units on the same side of each ratio and set the two ratios equal to each other:

IF ______________ = THEN ____________

ANSWER:

IF $\frac{10\text{ mg}}{2\text{cc}}$ = THEN $\frac{7.5\text{ mg}}{\text{“x” cc}}$

STEP 3: Cross multiply (mean times mean = extreme times extreme)

ANSWER:

IF $\frac{10\text{ mg}}{2\text{ cc}}$ THEN $\frac{7.5\text{ mg}}{\text{“x” cc}}$

STEP 4: 10 times “x” = 2 times 7.5

so, 10"x” = 15

ANSWER:

After cross multiplication we found that 10 “x” = 15

STEP 5: Solve for “x”:

Left Side $\frac{10}{10}$ = 1 or “x”

Note: We disregard the units on the numbers until we find the value of “x”. Upon finding the value of “x” we go to the original equation and obtain the unit of “x”.

ANSWER:

$$\text{Right Side } \frac{15}{10} = 1.5$$

$$\text{“x”} = 1.5$$

Note that after cross multiplication we found that 10 “x” is equal to 15. However, we do not want to find what 10 “x” is equal to--we want to know the value of 1 “x” (or it can easily be expressed as “x”). In order to find the value of 1 “x” (or “x”) in the case above, we must eliminate the number 10. The easiest way to remove 10 from the equation is to divide 10 “x” by 10. Just working with the left-hand side of the equation, the work would appear as follows:

$$\frac{10\text{“x”}}{10} \quad \text{or since } \frac{10}{10} = 1$$

$$\text{so,} \quad \frac{10\text{"x”}}{10} \text{ can be expressed as “x”}$$

BUT, REMEMBER what is done to one side of an equation must also be done to the other side of the equation. What does this mean?

This means basically that if one side of an equation is divided by a number, the other side of the equation must also be divided by that same number. How does that apply to the equation above?

Since the left side of the equation was divided by 10, then the right side of the equation must also be divided by 10.

$$\text{so,} \quad \frac{15}{10}$$

15 divided by 10 is equal to 1.5.

Let us view the whole equation of the things we have just discussed.

Let us start with the basic equation.

$$10\text{“x”} = 15$$

divide each side of the equation by 10 $\frac{10\text{“x”}}{10} = \frac{15}{10}$

Therefore, "X" = 1.5 cc

SO, 1.5 cc of the solution would contain 7.5 mg of the drug.

Now that you have worked a few example problems involving ratio and proportion principles, let's work more problems of this type. Remember: If you have difficulty working a problem, you should go back and review the basic principles of ratio and proportion. Also, be careful with mathematics--even if you have your problem correctly set up, an incorrect answer can arise from a failure to multiply or divide correctly.

PRACTICE PROBLEMS

1. a. $\frac{5}{10} = \frac{1}{\text{“x”}}$

5 times “x” = 10 times 1

5 “x” = 10

$\frac{5\ \text{“x”}}{5} = \frac{10}{5}$

“x” = ______

> ANSWER:
>
> “x” = 2

b. $\frac{2}{3} = \frac{6}{\text{“x”}}$

2"x" = 18

“x” = ______

ANSWER:

$$\frac{2\text{"x"}}{2} = \frac{18}{2}$$

$$\text{"x"} = 9$$

c. $\frac{1/2}{18} = \frac{9}{\text{"x"}}$

NOTE: If you desire, you could convert 1/2 into 0.5. Then you could express the equation as follows:0.5 times "x" = 9 times 18.

½ times "x" = 9 times 18

½ "x" = 162

½ "x" = 162

NOTE: In order to solve this equation, each side of the equation must be multiplied by 2.

SO, 2 times ½ "x" = 2 times 162

2 times 1/2 = 1
2 times 162 = 324

Therefore, "X" = 324

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d. $\frac{1/4}{16} = \frac{\text{"x"}}{0.8}$

"x" = ______________________

Now that you have had some practice in solving ratio-proportion problems which have been already set up for you, let's see how you can analyze a problem and solve for the unknown you are trying to find.

2. An order is received for 750 mg of Kanamycin. In supply you find Kanamycin labeled 1.0 gram per 3.0 cc. How many cc of solution must be sent to the ward in order to supply the needed amount of drug? (NOTE: 1 gram = 1,000 milligrams)

First, write the information you have in "IF-THEN" form

IF ____________ = THEN____________

Solve for"x"

"x" = __________ cc of solution provide 750 mg of drug

ANSWER:		
"x"	=	2.25cc

Notice that the "IF-THEN" statement may be written in one of two ways:

a. IF $\frac{1.0 \text{ gm}}{3.0 \text{ cc}}$ = THEN $\frac{0.750 \text{ gm}}{\text{"x" cc}}$

b: IF $\frac{1{,}000 \text{ mg}}{3.0 \text{ cc}}$ = THEN $\frac{750 \text{ mg}}{\text{"x" cc}}$

3. A vial of Phenergan is labeled 25 mg/cc. How many cc must be injected in order to administer a dose of 10 mg of the drug?

"x" ___________ cc of solution must be given to administer 10 mg

ANSWER: "x" - = 0.4 cc

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4. You receive a call from the Immunization Clinic. One of the new 91Bs wants to know how many shots he can give from a 10 cc vial if each injection required 0.3 cc.

"x" = ____________"shots" (each 0.3 cc) can be administered from the 10 cc vial

<u>ANSWER:</u> 33 "shots" (ech being 0.3cc) can be administered from the 10cc vial

<u>SOLUTION:</u>

$$\text{IF } \frac{1\text{ shot}}{0.3\text{ cc}} = \text{THEN } \frac{\text{"X" shots}}{10\text{ cc}}$$

$$(0.3) \text{ times } (\text{"x"}) = (1) \text{ times } (10)$$

$$0.3\text{ "x"} = 10$$

$$\frac{0.3\text{ "x"}}{0.3} = \frac{10}{0.3}$$

$$\text{"x"} = 33$$

$$\text{"x"} = 33 \text{ shots per 10 cc vial}$$

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5. An order calls for 15 milliequivalents (mEq) of potassium chloride (KCL) to be added to a liter of D5W. In supply you have potassium chloride solution in a strength of 2 mEq of KCL per cc. How many cc of the solution are required to obtain the 15 mEq of KCL.

"x" = ___________ cc of KCLsolution (2 meq/cc) will contain 15 mEq of KCL.

ANSWER: 7.5 cc of the solution will yield 15 meq of KCL

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6. A patient is to be administered 15 mg of diazepam (Valium). Valium is supplied in a concentration of 10 mg per 2 cc. How many cc of the drug solution will contain 15 mg of the drug?

"x" = ___________cc of the solution contain 15 mg of the drug.

ANSWER: "x" = 3 cc of the solution contains 15 mg of the drug.

7. You wish to administer 35 mg of diphenhydramine (Benadryl) Injection to a patient. The drug is supplied in a concentration of 50 mg per cc. How many cc's of drug solution would contain 35 mg of the drug?

"x"______________cc of the Benadryl Solution

<u>ANSWER</u>: "x" = 0.7cc of the Benadryl soln

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8. You are supplied with Lasix Injection, 20 mg/cc, 2 cc per vial. How many cc's of this solution must be used to administer 30 mg of the drug to a patient?

"x" = ________________ cc of the Lasix Injection, 2 mg/cc

<u>ANSWER</u>: "x" = 1.5 cc of the Lasix Injection, 20 mg/cc.

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9. You are supplied with Potassium Chloride Injection labeled 20 mEq per 10 cc. How many cols of this solution would you use to give a patient 25 mEq of Potassium Chloride?

"x" = ________ cc of the Potassium Chloride Injection (20 mEq/10 cc)

<u>ANSWER</u>: "x" = 12.5 cc of the Potassium Chloride Injection (20 mEq/10 cc)

<u>PRACTICE PROBLEMS FOR RATIO AND PROPORTION</u>

<u>NOTE</u>: Answers to problems are found on page 1-18

1. Solve for "x":

a. $\frac{3}{5} = \frac{x}{10}$

b. $\frac{5}{1} = \frac{2}{x}$

c. $\frac{1/2}{30} = \frac{0.6}{x}$

e. $\frac{0.25}{1} = \frac{1.5}{x}$

f. 5 "x" = 20

g. 0.2 "x" = 44

d. $\frac{0.8}{2} = \frac{5}{x}$

h. 2.2"x" = 154

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2. You have a vial of Ephedrine Injection labeled 25 mg per ml. How many ml must be injected in order to administer a dose of:

a. 12.5 mg ANSWER= __________ml

b. 30 mg ANSWER = __________ml

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3. How many milligrams of drug are contained in a 30 milliliter vial of Naloxone, a narcotic antagonist, labeled 0.4 mg per ml?

ANSWER =___________ mg

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4. In supply you find a vial of Kanamycin Injection labeled 1.0 gram per 3 milliliters. How many milliliters of this solution must be given to administer a dose of 1.2 grams of the drug?

ANSWER = ________________ml

ANSWERS:

1. a. 6
   b. 0.4
   c. 36
   d. 12.5
   e. 6
   f. 4
   g. 220
   h. 70

2. a. 0.5 ml
   b. 1.2 ml

3. 12 mg

4. 3.6ml