LEARNING OBJECTIVES

Upon completion of this module, the subscriber will be able to:

1. Compute pharmacy problems by using ratio and proportion or dimensional analysis.
2. Compare and convert units among the pharmacy math systems, especially the metric system.
3. Calculate quantity and day supply.
4. Calculate doses based on weight and body surface area.
5. Calculate intravenous (IV) flow rates.
6. Reduce and enlarge compounding formulas.
MEET THE AUTHOR

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Introduction

Correct pharmacy calculations are imperative to the practice of pharmacy. From the calculation of amounts of components being added to a compounded total parenteral nutrition (TPN) to the drops per minute rate on the label of an intravenous (IV) bag, pharmacy calculations can make a difference of life or death.

Being a pharmacy technician requires a variety of skills and abilities and perhaps most important is the ability to carry out important mathematic calculations. The goal of this module is to provide a basic review of the many types of pharmacy calculations that pharmacy technicians are asked to perform.

Unit 1: Basic Calculation Foundation
Ratio and Proportion and Dimensional Analysis

Ratio and Proportion

Ratio and proportion calculations are based on the concept that one component is in proportion to another. As a result, many calculations may be solved by setting the problem up as a ratio.

For example: 1 tablet contains 500mg. “One tablet contains 500mg” is the same as saying “500mg per 1 tablet”. Thus, this can be written as:

\[
\frac{500\text{mg}}{1\text{tab}} = \frac{X\text{mg}}{3\text{tab}}
\]

Using proportions we can determine a ratio that is equal to this ratio.

Example 1: If 1 tablet contains 500mg, how many milligrams are in 3 tablets?

\[
\frac{500\text{mg}}{1\text{tab}} = \frac{X\text{mg}}{3\text{tab}}
\]

Solving for \(x\), we find that there are 1500mg in 3 tablets. Because we used proportions, we know that the ratio of:

\[
\frac{500\text{mg}}{1\text{tab}} \quad \text{is equal to} \quad \frac{1500\text{mg}}{3\text{tab}}
\]

Example 2: If one teaspoonful (5ml) of a solution contains 15mg of medication, how many milligrams are there in 4 teaspoonsful or 20ml?

\[
\frac{15\text{mg}}{5\text{ml}} = \frac{X\text{mg}}{20\text{ml}}
\]

15mg x 20ml = Xmg x 5ml

\[
\frac{15\text{mg}}{5\text{ml}} = \frac{X\text{mg}}{5\text{ml}}
\]

\[
\frac{300\text{mg}}{5} = \frac{X\text{mg}}{1}
\]

\[
60\text{mg} = X\text{mg}
\]

So there are 60mg in 20mls or 4 teaspoons of the solution.
Dimensional Analysis

Dimensional Analysis is another method that may be used to calculate quantities of IV additives or strengths of doses. This method is based on cancelling out the units of measure or labels.

Example 1: If 1 tablet contains 500mg, how many milligrams are in 3 tablets?

*Step 1:* Find the ratio that is in the problem. In this case, the ratio is:

\[
\frac{500\text{mg}}{1\text{ tab}}
\]

*Step 2:* Set up the problem around the ratio so that the units cancel out. The unit that is left (ie. the unit that does not cancel out with the other units) should correspond to the unit needed for the answer to the problem. In this problem, the unit that we need is 'mg', since the problem asks how many milligrams are in 3 tablets.

\[
3\text{ tab} \times \frac{500\text{mg}}{1\text{ tab}} = 1500\text{mg}
\]

Example 2: A pharmacy technician must fill an order for three 1 liter bags of 5% dextrose in water (D5W) with 12mmols of potassium phosphate for one patient. The potassium phosphate is 3mmol/ml in 5ml vials. How many 5ml vials of potassium phosphate will the technician need to fill the patient's order?

\[
3 \text{ bags} \times \frac{12\text{ mmols}}{\text{bag}} \times \frac{1\text{ ml}}{3\text{ mmols}} \times \frac{1\text{ vial}}{5\text{ ml}} = 2.4\text{ vials}
\]

Practice

1. A prescription for a suspension calls for a dose of 250mg to be given twice a day. If the suspension contains 300mg/5ml, how many ml are needed for one dose?

2. A prescription calls for 2000mg of amoxicillin for one dose. If the pharmacy only carries 250mg capsules of amoxicillin, how many capsules will you need to fill this dose?

3. A patient injects 8 units of U-100 insulin each day. What is the volume in milliliters the patient needs to inject? (Hint: U-100 = 100 units of insulin/ml)

4. An order is written for 375mg of ampicillin to be given intravenously every 6 hours to a child weighing 15kg. Ampicillin is available in a 1g/50ml concentration. Calculate the volume in milliliters needed for a single 375mg dose.

5. An order is written for 2g of vancomycin to be given IV every 12 hours for an adult. Calculate the volume in milliliters needed for a single dose if vancomycin is available in a 50mg/ml concentration.

6. If there are 400,000 units of penicillin in 250mg of penicillin V potassium, how many units of penicillin will a patient receive in a 125mg dose of penicillin V potassium?

7. A patient injects 0.15 ml of insulin each morning. How many units of insulin are in each dose? (Hint: 100 units of insulin/ml)

*A Word About Rounding*

Often, it is more practical to round a number to the nearest whole number, tenth, or hundredth decimal place. When rounding, it is important to follow this rule: If the number to the right of the place for which you are rounding is less than 5, round down. If the number is 5 or greater, round up. For example, the answer to Practice Question 1 is actually 4.17 ml. Because it would be very difficult to measure this exact amount in an oral syringe, it is more practical to round the amount to a volume that is more practical to obtain. If we are using an oral syringe that measures to the tenths place, we could round the volume to the nearest tenth. Because the number to the right of the tenths place is greater than 5 (it is 7), we would round up, making the value 4.2ml. If we were to round to the nearest whole number, the value would be 4, since the number to the right of the whole number is less than 5 (it is 1).

Practice Answers

Question 1: 4.2ml
Question 2: 8 capsules
Question 3: 0.08ml
Question 4: 18.75ml
Question 5: 40ml
Question 6: 200,000 units
Question 7: 15 units
Unit 2: Measurement Systems Used in the Practice of Pharmacy

The Metric System

The metric system, also known as the International System of Units (SI), is a measurement system that pharmacists and technicians must know. The system uses ‘units’ and ‘prefixes’.

The ‘units’ most commonly used in the practice of pharmacy include:
- Gram (used as a measure of weight or drug strength)
- Meter (used as a measure of distance or area)
- Liter (used as a measure of volume)

These are sometimes referred to as the ‘base unit’.

The ‘prefixes’ most commonly used in the practice of pharmacy include:
- Kilo
- Milli
- Micro
- Nano

In the SI system, a prefix is paired with a base unit to help describe a measurement.

Examples:
- Kilo + Gram ➔ Kilogram
- Milli + Liter ➔ Milliliter

Metric System: Grams
(Note: Units of measure in bold are most commonly used in pharmacy practice)

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Name</th>
<th>Factor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilo</td>
<td>Kilogram (Kg)</td>
<td>$10^3$</td>
<td>1,000 grams</td>
</tr>
<tr>
<td>Hecto</td>
<td>Hectogram (hg)</td>
<td>$10^2$</td>
<td>100 grams</td>
</tr>
<tr>
<td>Deka</td>
<td>Dekagram</td>
<td>$10^1$</td>
<td>10 grams</td>
</tr>
<tr>
<td></td>
<td>Gram (g)</td>
<td></td>
<td>1 gram</td>
</tr>
<tr>
<td>Deci</td>
<td>Decigram (dg)</td>
<td>$10^{-1}$</td>
<td>0.1 gram</td>
</tr>
<tr>
<td>Centi</td>
<td>Centigram</td>
<td>$10^{-2}$</td>
<td>0.01 gram</td>
</tr>
<tr>
<td>Milli</td>
<td>Milligram (mg)</td>
<td>$10^{-3}$</td>
<td>0.001 gram</td>
</tr>
<tr>
<td>Micro</td>
<td>Microgram (mcg)</td>
<td>$10^{-6}$</td>
<td>0.000001 gram</td>
</tr>
<tr>
<td>Nano</td>
<td>Nanogram (ng)</td>
<td>$10^{-9}$</td>
<td>0.000000001 gram</td>
</tr>
</tbody>
</table>

Metric System: Liters
(Note: Units of measure in bold are most commonly used in pharmacy practice)

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Name</th>
<th>Factor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilo</td>
<td>Kiloliter (KL)</td>
<td>$10^3$</td>
<td>1,000 liters</td>
</tr>
<tr>
<td>Hecto</td>
<td>Hectoliter (hL)</td>
<td>$10^2$</td>
<td>100 liters</td>
</tr>
<tr>
<td>Deka</td>
<td>Dekaliter</td>
<td>$10^1$</td>
<td>10 liters</td>
</tr>
<tr>
<td></td>
<td>Liter (L)</td>
<td></td>
<td>1 liter</td>
</tr>
<tr>
<td>Deci</td>
<td>Deciliter (dL)</td>
<td>$10^{-1}$</td>
<td>0.1 liter</td>
</tr>
<tr>
<td>Centi</td>
<td>Centiliter</td>
<td>$10^{-2}$</td>
<td>0.01 liter</td>
</tr>
<tr>
<td>Milli</td>
<td>Milliliter (mL or ml)</td>
<td>$10^{-3}$</td>
<td>0.001 liter</td>
</tr>
<tr>
<td>Micro</td>
<td>Microliter (mcL)</td>
<td>$10^{-6}$</td>
<td>0.000001 liter</td>
</tr>
<tr>
<td>Nano</td>
<td>Nanoliter (nL)</td>
<td>$10^{-9}$</td>
<td>0.000000001 liter</td>
</tr>
</tbody>
</table>

Understanding Factors
Each prefix represents a power of 10 from the base unit.
## Metric System: Meters

(Note: Units of measure in bold are most commonly used in pharmacy practice)

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Name</th>
<th>Factor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilo</td>
<td>Kilometer (Km)</td>
<td>10^3</td>
<td>1,000 meters</td>
</tr>
<tr>
<td>Hecto</td>
<td>Hectometer (hm)</td>
<td>10^2</td>
<td>100 meters</td>
</tr>
<tr>
<td>Deka</td>
<td>Dekameter</td>
<td>10^1</td>
<td>10 meters</td>
</tr>
<tr>
<td></td>
<td><strong>Meter (m)</strong></td>
<td></td>
<td>1 meter</td>
</tr>
<tr>
<td>Deci</td>
<td>Decimeter(dm)</td>
<td>10^-1</td>
<td>0.1 meter</td>
</tr>
<tr>
<td>Centi</td>
<td>Centimeter (cm)</td>
<td>10^-2</td>
<td>0.01 meter</td>
</tr>
<tr>
<td>Milli</td>
<td><strong>Millimeter (mm)</strong></td>
<td>10^-3</td>
<td>0.001 meter</td>
</tr>
<tr>
<td>Micro</td>
<td>Micrometer (mcm)</td>
<td>10^-6</td>
<td>0.000001 meter</td>
</tr>
<tr>
<td>Nano</td>
<td>Nanometer (nm)</td>
<td>10^-9</td>
<td>0.000000001 meter</td>
</tr>
</tbody>
</table>

### Converting Units within the Metric System

There are a number of ways to convert between units in the metric system. Here are a couple of examples.

#### Method #1

Using the scale above, one can convert between units by following these directions:

1. Locate the prefix or unit that matches the unit that is given to you.
2. Locate the prefix or unit that matches the unit that is desired.
3. Count the number of units it takes to get to the desired unit, starting from the given unit. Note the direction you have to move to get to the desired unit. This will tell you how many spaces to move the decimal point of the number written before the unit that is given. If you move to the left to get to the desired unit, move the decimal point to the left. If you move to the right to get to the desired unit, move the decimal point to the right. Use zeros “0” as place holders.
4. Add the new unit to the numerical value.

**Example:** Convert 3g to kg.

**Step 1:** Locate prefix or unit that is given.

Metric System Scale
The smaller hash marks represent units that are not typically used in pharmacy. Please do not forget that these hash marks also represent units!
Step 2: Locate the prefix or unit that matches the unit that is desired.

Step 3: Count the number of units between step 1 and step 2.

I have to move 3 units to get to the desired unit. I have to move to the left. Therefore, I move the decimal point to the left.

0.0 . 0 . 3

In pharmacy, it is imperative to include a leading zero, to help reduce medication errors. Therefore, this value is written as:

0.003

Step 4: 3g is equivalent to 0.003kg

Method #2

Remembering the following conversions can also help in converting within the metric system:

1kg = 1000g
1g = 1000mg
1g = 1,000,000mcg
1g = 1,000,000,000ng

Keeping this in mind, you can use ratio and proportion or dimensional analysis to convert within the metric system.

Example: Convert 5kg to mg.

Ratio and Proportion

5kg \times \frac{1kg}{1000g} = \frac{5000g}{x} \quad \text{Solving for } x \quad \text{Then} \quad \frac{5000g}{Xmg} = \frac{1g}{1000mg} \quad \text{Solving for } X:

\frac{5000g}{Xmg} = \frac{1g}{1000mg} \quad X = 5,000,000mg

Dimensional Analysis

\frac{5kg}{1kg} \times \frac{1000g}{1g} \times \frac{1000mg}{Xmg} = 5,000,000mg
Practice

Complete the following conversions:

1. $\text{3mg} = \text{______g}$
2. $\text{5.4L} = \text{______ml}$
3. $\text{14mm} = \text{______m}$
4. $\text{30ml} = \text{______L}$
5. $\text{6g} = \text{________ng}$
6. $\text{12,000,000mcg} = \text{________g}$
7. $\text{100mcl} = \text{________ml}$
8. $\text{13g} = \text{________kg}$
9. $\text{26g} = \text{________mg}$
10. $\text{640ml} = \text{_______mcl}$

Apothecary System

Another measurement system used in pharmacy is the apothecary system. The apothecary system can be used for fluid measurements and weight measurements. Converting within the apothecary system may be done using ratio and proportion or dimensional analysis.

Apothecary Conversions:

<table>
<thead>
<tr>
<th>Fluid Measures</th>
<th>Weight Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 minim = 1 fluidrachm or fluidram</td>
<td>20 grains = 1 scruple</td>
</tr>
<tr>
<td>8 fluidrams = 480 minim = 1 fluidounce (fl oz)</td>
<td>3 scruples = 60 grains = 1 dram</td>
</tr>
<tr>
<td>16 fluidounces = 1 pint (pt)</td>
<td>8 drams = 480 grains = 1 ounce (oz)</td>
</tr>
<tr>
<td>2 pints = 32 fluidounces = 1 quart (qt)</td>
<td>12 ounces = 5760 grains = 1 pound (lb)</td>
</tr>
<tr>
<td>4 quarts = 8 pints = 1 gallon (gal)</td>
<td></td>
</tr>
</tbody>
</table>

Example: How many fluidounces are in 6 quarts?

\[
\text{Ratio and Proportion:} \\
\frac{6 \text{ quarts}}{8 \text{ pints}} \cdot \frac{X \text{ fluidounces}}{1 \text{ pint}} = \frac{12 \text{ pints}}{1 \text{ pint}} \\
\Rightarrow X = 192 \text{ fluidounces}
\]

\[
\text{Dimensional Analysis:} \\
\frac{6 \text{ quarts}}{4 \text{ quarts}} \cdot \frac{8 \text{ pints}}{16 \text{ fluidounces}} = \frac{1 \text{ pint}}{1 \text{ pint}} \\
\Rightarrow 192 \text{ fluidounces}
\]

Avoirdupois System

A third measurement system used in pharmacy is the avoirdupois system. This system is used in measuring weight. Oftentimes, the weight displayed on bulk powders and chemi-
cal packages are listed as an avoirdupois weight. However, many if not all compounding recipes require measurements to be made using the metric system. Converting within the avoirdupois system may be done using ratio and proportion or dimensional analysis.

**Avoirdupois conversions:**

1 kg = 2.2 lb
1 lb = 454 g

**Example:** A young child weighs 45 lb. How much does this child weigh in kilograms?

**Ratio and Proportion**
\[
\frac{45 \text{ lb}}{1 \text{ kg}} = \frac{2.2 \text{ lb}}{X \text{ kg}}
\]
Solving for X:
\[
X = \frac{20.5 \text{ kg}}{1 \text{ kg}}
\]

**Dimensional Analysis**
\[
\frac{45 \text{ lb}}{2.2 \text{ lb}} \times 1 \text{ kg} = 20.5 \text{ kg}
\]

**Household System**

A fourth system of measure that pharmacists and technicians should be familiar with is the household system. Converting within the household system may be done using ratio and proportion or dimensional analysis.

One must be familiar with the following abbreviations in order to use this system:

- 1 tsp = 5 ml
- 1 tbs = 3 tsp
- 1 cup = 8 oz
- 2 tbs = 1 oz
- 1 oz = 30 ml
- 1 pt = 2 cups
- 16 oz = lb (weight)
- 1 qt = 4 cups = 2 pt

**Practice Answers**

Question 1: 154 lb; Question 2: 0.3125 pint; Question 3: 384 fluidounces; Question 4: 4.5 oz; Question 5: 5.45 kg; Question 6: 2 fluid drams; Question 7: 908 g; Question 8: 2 tsp; Question 9: 1440 grains; Question 10: 84 oz

**Practice**

Complete the following conversions:

1. 70 kg = ________ lb (avoirdupois)
2. 5 fluidounces = ______ pint
3. 3 gallons = ________ fluidounces
4. 9 tbs = ________ oz
5. 12 lb = ________ kg
6. 120 minim = ________ fluidram
7. 2 lb = ________ g (avoirdupois)
8. 2 tbs = ________ tsp
9. 3 ounces = ________ grains
10. 7 pounds = ________ oz (apothecary)
Unit 3: Calculation of Quantity and Day Supply

In order to calculate quantity and day supply, it is important to understand unit of measure and Latin abbreviations used on prescriptions. A review of unit of measure abbreviations and Latin abbreviations are beyond the scope of this review. Readers are encouraged to refer to the Pharmacy Calculation Practice Resources and References (listed on pages 24-25 in this module) or other manuals to review pharmacy abbreviations.

In many instances, the quantity of medication that needs to be dispensed is listed on the prescription. However, there are instances when this is not the case. In these situations, it is important that the pharmacist or technician knows how to calculate this amount. There are a number of scenarios that the pharmacist or technician may find themselves in when dealing with quantity and/or day supply.

Scenario #1: Calculating the quantity of a dose when the dose is given in milligram strength.

Many times, the quantity (or dose) is provided. It may be referred to as the number of tablets or capsules needed, or the amount of milliliters needed. However, there are some times when the dose is listed in milligram strength, and you may need to determine how many tablets, capsules, or milliliters are needed so that the prescription can be properly dispensed.

You may use the following steps to calculate quantity when the dose is given in milligrams (mg):

1. Determine the ratio of milligram of drug per dosage form.
2. Using ratio and proportion or dimensional analysis, calculate the equivalent amount of dosage form needed to equal the milligram strength.

Example: A prescription was written for 750mg dose of drug X. There are 500mg of drug X in 1 tablet. How many tablets are needed to receive the 750mg dose?

\[
\begin{align*}
\text{Ratio and Proportion} \\
750\text{mg} & = 500\text{mg} \\
X \text{ tab} & = 1\text{tab} \\
\text{Solving for } X: \\
X & = 1.5 \text{ tab}
\end{align*}
\]

\[
\begin{align*}
\text{Dimensional Analysis} \\
750\text{mg} \times \frac{1\text{tab}}{500\text{mg}} & = 1.5 \text{ tab}
\end{align*}
\]

Scenario #2: Calculating the quantity of drug needed to be dispensed for a stated day supply.

You may use the following steps to calculate the quantity needed to be dispensed for a stated day supply:

1. Determine the amount of agent (ie, tablets, capsules, milliliters, etc) needed per dose.
2. Determine how many doses are given per day based on the dosing schedule.
3. Determine the amount of agent (ie, tablets, capsules, milliliters, etc) needed for one day.
4. Determine how many days the prescription is written for. Then, calculate the amount of agent needed for the amount of days the prescription will be taken.
Example: A prescription was written for 750mg dose of drug X to be taken 3 times a day for 10 days. There are 500mg of drug X in 1 tablet. How many tablets should be dispensed for a 10-day supply?

Ratio and Proportion

Step 1:
\[
\frac{750 \text{ mg}}{500 \text{ mg}} = \frac{X \text{ tabs}}{1 \text{ tab}}
\]
Solving for X:
\[
X = 1.5 \text{ tabs}
\]

Steps 2 and 3: The instructions call for 3 doses per day.
\[
\frac{1.5 \text{ tabs}}{1 \text{ dose}} = \frac{X \text{ tabs}}{3 \text{ doses}}
\]
Solving for X:
\[
X = 4.5 \text{ tabs}
\]

Step 4: The prescription is written for 10 days.
\[
\frac{4.5 \text{ tabs}}{1 \text{ day}} = \frac{X \text{ tabs}}{10 \text{ days}}
\]
Solving for X:
\[
X = 45 \text{ tablets}
\]

Dimensional Analysis

Step 1:
\[
\frac{750 \text{ mg}}{500 \text{ mg}} \times \frac{1 \text{ tab}}{500 \text{ mg}} = 1.5 \text{ tabs}
\]

Steps 2 and 3: The instructions call for 3 doses per day.
\[
\frac{3 \text{ doses}}{1 \text{ dose}} \times \frac{1.5 \text{ tabs}}{1 \text{ dose}} = 4.5 \text{ tabs}
\]

Step 4: The prescription is written for 10 days.
\[
\frac{4.5 \text{ tabs}}{1 \text{ day}} \times \frac{10 \text{ days}}{1 \text{ day}} = 45 \text{ tablets}
\]

Scenario #3: Calculating the day supply when the quantity of drug needed to be dispensed, and dosing schedule is stated.

Making this calculation is oftentimes done automatically through the computer system. However, it is helpful for the pharmacist or technician to know how to do this calculation. You may use the following steps to perform this calculation.

1. Determine how much of the agent (ie. tablet, capsule, milliliters) is needed per dose, if it is not stated.
2. Determine how many doses per day are given.
3. Multiply Step 1 and Step 2 to determine the total amount of agents (ie, tablets, capsules, milliliters) given in one day.
4. Using ratio and proportion or dimensional analysis, calculate the number of days (ie. day supply) the prescription provides. Please note that this problem can also be solved using simple division.

Example: A prescription is written for the patient to take 2 tablets Q 8 hours. The prescription calls for 180 tablets to be dispensed. How long will this prescription last? Calculate the day's supply.
**Ratio and Proportion**

*Step 1:* The prescription tells us that one dose consists of 2 tablets.

*Step 2:* The instructions call for 3 doses per day.

*Step 3:* 2 tablets x 3 doses = 6 tablets per day

*Step 4:* \[
6 \text{ tabs} = 180 \text{ tabs} \quad \text{Solving for X:}
\]

\[
\frac{1 \text{ day}}{X \text{ days}} = \frac{30 \text{ days}}{X \text{ days}}
\]

Therefore, this prescription is for a 30 day supply.

**Dimensional Analysis**

*Step 1:* The prescription tells us that one dose consists of 2 tablets.

*Step 2:* The instructions call for 3 doses per day.

*Step 3:* 2 tablets x 3 doses = 6 tablets per day

*Step 4:* \[
\frac{180 \text{ tab} \times 1 \text{ day}}{6 \text{ tab}} = 30 \text{ days}
\]

Therefore, this prescription is for a 30 day supply.

**Practice**

Complete the following problems.

1. How many days will the following prescription last?
   - Rx: Nitrofurantion 100mg capsules
     #28 capsules
   - Sig: i cap po QID

2. A loading dose of 2g is ordered for an antibiotic suspension. If the suspension is available in 250mg/ml, how many milliliters are needed for this dose?

3. A prescription is written as follows:
   - Prednisone 10mg tablets
   - 20mg po BID x 2 days
   - 20mg po once daily x 2 days
   - 10mg po once daily x 2 days

   a. How many tablets are needed for each 2 day regimen?
   b. How many days does this prescription last?
   c. How many tablets need to be dispensed?

**Practice Answers**

Question 1: 7 days; Question 2: 8ml; Question 3a: First 2 days: 8 tablets, Second 2 days: 4 tablets, Third 2 days: 2 tablets; Question 3b: 6 days; Question 3c: 14 tablets
Unit 4: Calculation of Doses\textsuperscript{3,4}  
(Weight Based, Body Surface Area)

Sometimes, a medication is dosed based on a person’s weight or body surface area.

Weight based dosing

Weight based doses are most often calculated by using a patient’s weight in kilograms (kg). In order to do this, one must know the conversion from pounds (lb) to kilograms (kg). This dosing method is usually done with pediatric dosing.

\[ 1 \text{kg} = 2.2 \text{ lb} \]

Another key point to remember with weight based dosing is that the dose is determined based on milligram of drug per kilogram of body weight. One can calculate weight based dosing easily using ratio and proportion or dimensional analysis.

**Example:** The dose of an antibiotic is 40mg/kg twice daily. How much of the antibiotic per dose should be given to a patient who weighs 80 lb?

**Ratio and Proportion**

**Step 1:** Convert weight from pounds to kilograms.

\[
\frac{1 \text{kg}}{2.2 \text{ lb}} = \frac{X \text{ kg}}{80 \text{ lb}}
\]

Solving for X:

\[
X = 36 \text{ kg}
\]

**Step 2:** Calculate dose.

\[
\frac{40 \text{ mg}}{1 \text{ kg}} = \frac{X \text{ mg}}{36 \text{ kg}}
\]

Solving for X:

\[
X = 1440 \text{ mg}
\]

**Dimensional Analysis**

Steps 1 and 2 can be done together.

\[
\frac{80 \text{ lb}}{2.2 \text{ lb}} \times \frac{1 \text{ kg}}{X} \times \frac{40 \text{ mg}}{1 \text{ kg}} = 1440 \text{ mg}
\]

Dosing Based on Body Surface Area (BSA)

Some medications, such as chemotherapy agents, are dosed based on BSA. In addition, some medications that will be administered to pediatric patients will be dosed based on BSA. Most times, a nomogram is used to calculate the BSA. A review of the BSA equation and/or how to use a nomogram is outside the scope of this review. For the purpose of this review, the BSA will be provided.

One can also calculate doses based on milligram per m\textsuperscript{2}. One will still need to know the BSA for this calculation. Calculations using mg/m\textsuperscript{2} can be easily completed using ratio and proportion or dimensional analysis.
Example: The dose for a drug is 5mg/m². Calculate the dose for a patient with a BSA of 1.25m².

\[
\begin{align*}
\text{Ratio and Proportion} & \\
\frac{5\text{mg}}{m^2} &= \frac{X\text{mg}}{1.25m^2} \\
\text{Solving for } X & \\
X &= \frac{6.25\text{mg}}{m^2}
\end{align*}
\]

Dimensional Analysis

\[
\frac{1.25m^2 \times 5\text{mg}}{m^2} = \frac{6.25\text{mg}}{m^2}
\]

Practice
Complete the following problems.

1. The dose of a pain medication is 5mg/kg. Calculate the dose for a patient that weighs 36kg.

2. An antibiotic is dosed at 80mg/kg/day, divided in 2 doses. Calculate the dose, in milligrams of a single dose for a child weighing 30 lb. What is the total daily dose given?

3. The dose of paclitaxel is 260mg/m². Calculate the dose that should be given to a patient that has a body surface area of 1.51m².

Unit 5: Intravenous (IV) Flow Rates

In certain instances, it is necessary for medications to be given by intravenous route. These medications are typically added to IV solutions such as normal saline (NS), 5% dextrose in water (D5W), or Lactated Ringers (LR). The medication is then delivered into the vein by using an infusion pump or regulated manually. In order for the solution to be delivered properly, a flow rate has to be determined. Flow rates for infusion pumps are typically written in ml/hr. Manually regulated flow rates are typically written in drops/minute.

Calculating the flow rate

A flow rate can be calculated in multiple ways, depending on which type of information is provided.

Calculating flow rate when a particular volume and assigned time frame is given, when using an infusion pump

Because the flow rate can be described as volume/time, if one is given a standard volume and a standard time, then flow rate can be determined simply by placing the volume, in milliliters, over minutes or hours.
Example: 3L of D5W is to be infused over 24 hours. Calculate the flow rate.

\[
\frac{3000\text{ml}}{24\text{ hours}} = 125\text{ml/hr}
\]

Calculating flow rate when using manual flow regulation

Calculating flow rate when the infusion is to be regulated manually can be done by using the following equation:

\[
\frac{\text{Volume (ml)} \times \text{drop factor}}{\text{Time in minutes}} = \text{flow rate}
\]

The drop factor is a value that describes how many drops are contained in milliliter of solution. The drop factor is determined by the type of tubing used.

Example: 3L of D5W is to be infused over 24 hours, using an IV set that delivers 15gtt/ml. Calculate the flow rate.

\[
\frac{3000 \times 15\text{gtt/ml}}{1440\text{ minutes}} = 31.25\text{ drops/minute or 31 drops/minute}
\]

In some cases, a flow rate may be written in mg/min. In these situations, one must convert the mg to the amount of volume, in milliliters.

Example: 3000mg of a drug is placed in 600ml of NS, and is ordered to be given at a rate of 10mg/min. Calculate the flow rate in ml/hr.

Step 1: Convert the mg/min to ml/min using ratio and proportion or dimensional analysis.

Step 2: Determine the flow rate in ml/hr

Ratio and Proportion

Step 1: Convert the mg/min to ml/min.

\[
\frac{3000\text{mg}}{600\text{ml}} = \frac{10\text{mg}}{X\text{ml}}
\]

Solving for X:

\[
\frac{600\text{ml}}{X\text{ml}} = X = 2\text{ml}
\]

Therefore, 2ml of solution contains 10mg of drug.

Step 2: Determine the flow rate in ml/hr.

Since 2ml contains 10mg, you are essentially giving 2ml/minute.

\[
\frac{2\text{ml}}{60\text{min}} = \frac{X\text{ml}}{60\text{min}}
\]

Solving for X:

\[
X = 120\text{ml/hr}
\]

Dimensional Analysis

Steps 1 and 2 can be done together.

\[
\frac{10\text{mg}}{60\text{min}} \times \frac{600\text{ml}}{X\text{ml}} \times \frac{60\text{min}}{3000\text{mg}} = 120 \text{ ml/hr}
\]
Practice

Complete the following problems.

1. 4L of Lactated Ringers is to be infused over 20 hours by infusion pump.
   a. Calculate the flow rate in ml/hr.
   b. Calculate the flow rate in gtt/min when infused with an IV set with a drop factor of 12gtt/ml.

2. An order is written for 375ml of D5W to be administered over 6 hours.
   a. Calculate the flow rate of an infusion given with an IV set that has a drop factor of 20gtt/min.
   b. Calculate the administration rate in ml/hr.

3. 50 mg of a drug is added to 500ml of 0.45% sodium chloride or NaCl (1/2 NS). Calculate the flow rate in ml/hr needed in order to administer the drug so that it is delivered at a rate of 5mg/hr.

Unit 6: Reducing and Enlarging Formulas

Pharmacists and technicians must use a recipe, or formula, when compounding medications. These recipes, much like recipes found in cookbooks, are designed to make a certain amount of the end product. On occasion, a prescription may call for more or less of the product than what the recipe is written for. In these situations, the recipe or formula, must be enlarged or reduced.

There is a simple equation that can be used when reducing and enlarging formulas:

\[
\frac{\text{Quantity of formula specified}}{\text{Quantity of formula desired}} = \frac{\text{Quantity of ingredient specified}}{X}
\]

To use this equation, it is important to know that the quantity specified refers to the quantity that is listed in the recipe or formula. The quantity desired is the quantity ordered in the prescription, or in other words, the quantity that you want to make.

Example: The following recipe makes 10 capsules:

- Drug X 2g
- Starch 20mg

How much of Drug X is needed to make 25 capsules?

\[
\frac{10 \text{ caps}}{25 \text{ caps}} = \frac{2g}{Xg} \quad \text{Solving for } X:
\]

\[
X = 5g
\]
Practice

Complete the following problems.

1. A prescription for an oral suspension calls for 240ml to be dispensed. The recipe for the solution is as follows:

- Tamiflu® 75mg capsules 1.5 g
- Cherry syrup qs 50 ml

a. Calculate the number of Tamiflu® 75mg capsules that will be needed to compound the 240ml of suspension.
b. Calculate the amount of Tamiflu® in grams needed to make 240ml of the solution.

2. A prescription for a topical ointment calls for 45g to be dispensed. The recipe for the solution is as follows:

- Betamethasone valerate 121mg
- Alcohol (95%) 20ml
- Propylene glycol 20ml
- Pluronic® F127 22g
- Purified water qs 100g

Calculate the amount of each ingredient needed to make 45g of the solution.

Unit 7: Calculation of Percent Strength

Certain medications, when available as a solution or a solid dosage form can be referred to by the percent strength. Percent strength can be thought of as the parts of a drug contained in 100 parts of a product. Percent strength is expressed as:

- Weight/Volume (w/v)
- Weight/Weight (w/w)
- Volume/Volume (v/v)

Units play a very important role when calculating percent strength. Weight is always measured in grams, and volume is always measured in milliliters.

<table>
<thead>
<tr>
<th>Percent Strength</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Weight/Volume</td>
<td>The number of grams in every 100 milliliters of product (or solution)</td>
</tr>
<tr>
<td>% Weight/Weight</td>
<td>The number of grams in every 100 grams of product</td>
</tr>
<tr>
<td>% Volume/Volume</td>
<td>The number of milliliters in every 100 milliliters of product (or solution)</td>
</tr>
</tbody>
</table>
Examples using %w/v:

If the percent strength is known along with the volume of the solution, the amount of drug, in grams, can be determined.

Example: A certain antibiotic solution is available in a 1% (w/v) concentration. Calculate the amount of antibiotic, in grams, present in 50ml of this 1% solution.

**Ratio and Proportion**

\[
\frac{1g \text{ antibiotic}}{100ml \text{ solution}} = \frac{X}{50ml}
\]

Solve for X

\[X = 0.5g\]

**Dimensional Analysis**

\[
50ml \times \frac{1g \text{ antibiotic}}{100ml} = 0.5g
\]

If the drug amount is available along with the volume of the solution, the percent strength can be determined.

Example: Calculate the percent strength of a 400ml solution that contains 6g of a drug.

\[
\frac{6g}{400ml} \times 100\% = 1.5\% \quad \text{or} \quad \frac{6g}{400ml} = \frac{X\%}{100\%}
\]

Solve for X

\[X = 1.5\%\]

Examples using %w/w

Example 1: How much hydrocortisone is available in a 60g tube of hydrocortisone cream 2.5%?

**Ratio and Proportion**

\[
\frac{2.5g \text{ hydrocortisone}}{100g \text{ cream}} = \frac{X}{60g}
\]

Solve for X

\[X = 1.5g\]

**Dimensional Analysis**

\[
60g \times \frac{2.5g \text{ hydrocortisone}}{100g \text{ cream}} = 1.5g
\]

Example 2: Calculate the percent strength of a 15g gel that contains 375mg of drug.

First, you must convert the 375mg to grams. 375mg = 0.375g

\[
\frac{0.375g \text{ hydrocortisone}}{15g \text{ gel}} \times 100\% = 2.5\%
\]

or

\[
\frac{0.375g \text{ hydrocortisone}}{15g \text{ gel}} = \frac{X\%}{100\%}
\]

Solving for X

\[X = 2.5\%\]

Percent Strength Calculations
Remember, percent strength calculations must be done using grams, not milligrams.
Examples using % v/v:

Example 1: Calculate the amount of alcohol in 1L of a 70% solution.

\[
\frac{70 \text{ ml alcohol}}{100 \text{ ml solution}} = \frac{X \text{ ml}}{1000 \text{ ml}}
\]

Solving for \(X\)

\[
X = 700 \text{ ml}
\]

Example 2: A 30ml of a liquid astringent was mixed with 200ml of lotion. Calculate the percent strength of the mixture.

\[
\frac{30 \text{ ml}}{200 \text{ ml}} \times 100\% = 15\%
\]

or

\[
\frac{30 \text{ ml}}{200 \text{ ml}} = \frac{X\%}{100\%}
\]

Solving for \(X\)

\[
X = 15\%
\]

Practice

Complete the following problems.

1. Calculate the percent strength of a 500ml solution that contains 250 mg of drug.

2. A patient received 800ml of 5% dextrose in water (D5W) over a time span of 24 hours. How many grams of dextrose did this patient receive?

3. How many milligrams of clotrimazole are available in a 30 gram tube of clotrimazole 1% cream?

Striving for Accuracy in Pharmaceutical Calculations

The National Coordinating Council for Medication Error Reporting and Prevention defines a medication error as

\[
A \text{ medication error is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing; order communication; product labeling, packaging, and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use.}^{10}
\]

Performing accurate calculations can prevent medication errors in the area of medication prescribing, product labeling, product preparation, as well as medication administration and use. The following cases demonstrate how a calculation error in the product preparation resulted in a medication error.
Case 1

An order for caffeine citrate was ordered for a 4 pound neonate in the neonatal intensive care unit (NICU). The order was written as follows:

\[
\text{Caffeine citrate 10mg/ml} \\
\text{20mg/kg bolus x 1, then 5mg/kg/day}
\]

The technician compounded an extemporaneous solution of caffeine citrate and then proceeded to fill the prescription. The technician calculated the dose needed for the bolus to be 36 mg, and the maintenance dose to be 9 mg. He then prepared the prescription, drawing up 3.6 ml of the solution into an oral syringe for the bolus dose, and 0.9 ml into a second syringe to be placed in the unit dose cart for later delivery. The pharmacist on duty checked the syringes and sent the bolus dose to the NICU. Two hours later, the neonate was found to have tachycardia. Shortly after that, the neonate began to seize. Labs were drawn, in which the neonate was discovered to have a toxic caffeine serum concentration of 80 mg/L. After an investigation, it was determined that there was an error with the caffeine citrate compounded product. Compounding calculations were reviewed, and it was discovered that the caffeine citrate was prepared in a concentration of 100mg/ml, rather than 10mg/ml.

In this example, the technician calculated the correct dose for the patient. However, the error in calculation occurred during the extemporaneous preparation of the caffeine citrate. The recipe for caffeine citrate calls for 10 g of caffeine base and 10 g of citric acid to be mixed in 1L of sterile water. Unfortunately, when converting the liter to milliliters, the technician multiplied by a factor of 100, rather than 1000. As a result, the technician dissolved the caffeine and the citric acid in 100ml of sterile water rather than 1000 ml. This error resulted in the final product being 10 times more concentrated, thereby causing the patient to receive too much drug.

**Technician’s Calculation (incorrect calculation)**

\[
\begin{align*}
1L &= 100ml \text{ (source of the error)} \\
10g &= 10,000mg \\
\text{Actual concentration of preparation} &= \frac{10,000mg}{100ml} = 100mg/ml \quad \text{Resultant dose of 3.6ml of preparation} \\
\frac{100mg}{3.6ml} &= x \\
x &= 360mg \text{ of caffeine citrate}
\end{align*}
\]

**Correct Calculation**

\[
\begin{align*}
1L &= 1000ml \quad 10g = 10,000mg \\
\text{Actual concentration of preparation} &= \frac{10,000mg}{1000ml} = 10mg/ml \quad \text{Resultant dose of 3.6ml of preparation} \\
\frac{10mg}{3.6ml} &= x \\
x &= 36mg \text{ of caffeine citrate}
\end{align*}
\]
Case 2

A prescription is written for 200 mg of an antibiotic to be given by mouth every 8 hours for 10 days. The antibiotic comes in an oral suspension in a concentration of 100mg/5ml, and is available in a 150ml bottle. One bottle of the antibiotic costs $600. The technician filled the prescription and reconstituted 6 bottles of the antibiotic and prepared the label for the pharmacist to check. The pharmacist, visibly upset, looked at the technician and stated “you’ve just cost us $2,400 dollars”.

This is an example in which an incorrect medication calculation did not necessarily harm a patient, but was nonetheless an expensive error. In this case, the technician calculated the total bottles needed to be dispensed as if the medication were to be given 8 times a day rather than 3 times a day. Had this calculation been missed, the patient may have thought that the remaining medication should be saved for use at a later date, or may have continued to take the medication until all 6 bottles were taken. If this medication were not covered on the patient’s insurance plan, or if the patient was a cash paying customer, they may have paid for medication that they did not need.

**Technician’s Calculation (incorrect calculation)**

<table>
<thead>
<tr>
<th>Dose in milliliters</th>
<th>Total volume per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>100mg 5ml</td>
<td>200mg X</td>
</tr>
<tr>
<td>Solving for X: 10ml x 8 times a day = 80ml (source of error)</td>
<td></td>
</tr>
<tr>
<td>X = 10ml per dose</td>
<td></td>
</tr>
</tbody>
</table>

**Total volume for 10 days**

80 ml/day x 10days = 800ml

**Total bottles to dispense**

1 bottle = X bottles

Solving for X:

150 ml 800 ml X = 5.3 bottles or 6 bottles

**Total cost of 6 bottles**

$600 x 6 bottles = $3600

**Correct Calculation**

<table>
<thead>
<tr>
<th>Dose in milliliters</th>
<th>Total volume per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>100mg 5ml</td>
<td>200mg X</td>
</tr>
<tr>
<td>Solving for X: 10ml x 3 times a day = 30ml</td>
<td></td>
</tr>
<tr>
<td>X = 10ml per dose</td>
<td></td>
</tr>
</tbody>
</table>

**Total volume for 10 days**

30ml x 10days = 300ml

**Total bottles to dispense**

1 bottle = X bottles

Solving for X:

150ml 300ml X = 2 bottles

**Total cost of 2 bottles**

$600 x 2 bottles = $1200

**Cost of calculation error**

$3600-$1200 = $2400
Tips to help minimize calculation errors

Pharmacy technicians play a very important role in the prescription filling process, and play a very important role in ensuring that patients receive not only the correct medication, but also the correct medication dose. In order to do this, pharmacy technicians must be able to confidently and accurately calculate doses for prescription orders. Adoption of a few tips such as those listed below can help minimize the chances of making a calculation error.

1. **Show your work:** While attempting to perform simple calculations in your head, it is important to remember that a simple error can lead to severe medical misadventures and even death. Therefore, even the simplest pharmacy calculation should be completed on paper. There are a number of activities that take place simultaneously in the pharmacy. As a result, the chances of becoming distracted or interrupted while performing a calculation are very high. Doing something such as working a calculation on paper can help you to stay focused. Additionally, if you are interrupted, you have a record of where in the calculation you were before you had to stop.

2. **Include units in all calculations:** When performing calculations using the dimensional analysis method, including units is imperative. However, including units when using the ratio and proportion method is just as important. Including the units in the calculation can not only help determine if the calculation is set up properly, units can also provide a cursory way to initially double check your answer. For example, if a dose is needed in milliliters, but the answer after calculating the dose is in milligrams, this should be a key sign that the calculation was performed inaccurately.

3. **Use leading zeros left of the decimal:** Writing a dose or volume without a leading zero can lead to a major dosing error. A dose of “.5mg” can be mistaken as “5mg”, or when written by hand, “1.5mg”. To prevent this error from occurring, technicians should make it a habit to add the leading zero, so that “.5 mg” is written as “0.5mg”.

4. **Check, check and check again:** After performing the calculation, ask if the answer makes sense, especially if the dosing, day supply, or quantity dispensed seems unusually higher or lower than what is typically seen. For example, if a calculation results in dispensing 10 bottles of an antibiotic to a child, when only one bottle is usually dispensed, there may be an error in calculation due to a misplaced decimal point, incorrect metric conversion, or the addition of an extra zero by mistake.

Summary

Pharmacy technicians, regardless of the practice setting, will have the responsibility of performing pharmacy calculations. Whether calculating the day supply of an oral medication, drawing up an IV dose for a neonate, preparing an IV admixture, or compounding an extemporaneous preparation, performing an accurate calculation is a very important step in the process. The process of performing accurate calculations involves becoming confident in computing calculations. One can develop confidence with practice and periodic review of pharmacy calculation concepts. Incorporating tips to help minimize calculation errors is also important when performing accurate pharmacy calculations.
Pharmacy Calculation Practice Resources

The following texts are great sources to refer to for more practice with calculations as well as for an overview of basic calculation concepts.

**ASHP Pharmacy Technician Certification Review and Practice Exam, 3rd Ed**
Author: Barbara Lacher
ISBN: 978-1-58528-208-1

*This text is designed to help technicians prepare for the certification exam. This text provides a review on calculations. This text comes with a CD that contains additional practice questions to aid in preparing for the certification exam.*

**Manual for Pharmacy Technicians, 4th Ed**
Editor: Bonnie S. Bachenheimer BS, PharmD
ISBN: 978-1-58528-207-4

*This text provides an overview of the many functions related to the pharmacy technician. There is one chapter dedicated to pharmacy calculations in this text.*

**Math Calculations for Pharmacy Technicians**
Authors: Robert and Eugenia Fulcher

*This text provides an overview of calculations performed in inpatient and outpatient pharmacy. Each chapter provides practice problems, however the answer key only provides answers for the odd numbered problems.*

**Math for Pharmacy Technicians**
Author: Lorraine C. Zentz

*This text provides a concise, step by step method of performing pharmacy calculations performed in inpatient and outpatient settings. Each chapter provides practice problems as well as a chapter quiz. The second half of the book provides an answer key. Each answer in the key is worked out, to help the student understand the calculation methods used.*

**Pharmaceutical Calculations, 13th Ed**
Author: Howard Ansel, PhD.
ISBN: 978-1-58255-837-0

*This text provides a comprehensive overview of calculations performed in inpatient and outpatient pharmacy. Each chapter provides a multitude of practice problems along with answer keys. Additionally, this text has a web component that provides access to a quiz bank, thus allowing further calculation practice.*

**Pharmaceutical Calculations for the Pharmacy Technician, 1st Ed**
Author: Barbara Lacher

*This text provides a comprehensive, yet easy to understand overview of pharmacy calculations performed in inpatient and outpatient pharmacy. Each chapter provides a number of problems, which are review sets and practice problems. An answer key is available for the review sets in the back of the text. This text also comes with a CD that contains more practice problems and a quiz bank, as well as a website that offers more practice problems.*
References


