# Chapter 5

## Problems Solving Methods

*The essence of mathematics is not to make simple things complicated, but to make complicated things simple.*
*--Stanley Gudder*

Most calculations in pharmacy can be solved using either ratios and proportions or dimensional analysis (*a.k.a.*, factor labels).

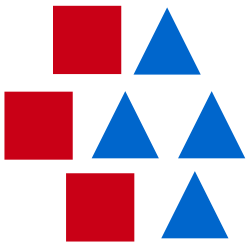
**Ratios**

We use ratios to make comparisons between two things. When we express ratios in words, we use the word "to" -- we say "the ratio of something to something else"

***Example :***

The ratio of squares to triangles in the illustration below. Ratios can be written in several different ways:

| | |
|---|---|
| as a fraction | $\frac{3}{4}$ |
| using the word “to” | 3 to 4 |
| using a colon | 3:4 |



Using the above images, make a comparison of triangles to all shapes written the following ways:

1) as a fraction
2) using the word “to”
3) using a colon

1) 4/7 2) 4 to 7 3) 4:7

Multiplying or dividing each term by the same nonzero number will give an equal ratio.

***Example*** :

The ratio 2:4 is equal to the ratio 1:2. To tell if two ratios are equal, use a calculator and divide. If the division gives the same answer for both ratios, then they are equal.

$$1:2 = 2:4 = 4:8 = 6:12 \qquad \textit{or} \qquad \frac{1}{2}=\frac{2}{4}=\frac{4}{8}=\frac{6}{12}$$

Are 3:9, 1:3, and 9:27 all equal?

Yes, 3:9 = 1:3 = 9:27

***Example*** :

Janine has a bag with 3 videocassettes, 4 marbles, 7 books, and 1 orange.

1) What is the ratio of books to marbles?
   - Expressed as a fraction, with the numerator equal to the first quantity and the denominator equal to the second, the answer would be 7/4.
   - Two other ways of writing the ratio are 7 to 4, and 7:4.

2) What is the ratio of videocassettes to the total number of items in the bag?
   - There are 3 videocassettes, and 3 + 4 + 7 + 1 = 15 items total.
   - The answer can be expressed as 3/15, 3 to 15, or 3:15.

Complete the following practice problems.

1) 
What is the ratio of squares to total?

2) 
What is the ratio of circles to triangles?

3) 
What is the ratio of triangles to squares?
What is the ratio of circles to all?
What is the ratio of triangles to squares to circles?

1) 7:8  2) 7:2  3) 3:2 ; 4:9 ; 3:2:4

Attempt the following practice word problems.

1) Write a ratio comparing the oxygen tension of arterial blood (100 milliliters) to that of venous blood (40 milliliters).

2) If 2 oz of boric-acid are added to 598 oz of water, how many ounces are in the total solution? What is the ratio of ounces of boric acid to ounces of solution?

3) If 35 oz of a chemical are combined with 65 oz of water, how many oz are in the solution? What is the ratio of oz of chemical to oz of solution?

1) 100:40 would be an acceptable answer, I would also accept it if someone reduced it down too 5:2  2) There are 600 ounces in the total solution and the ratio of boric acid to solution is 2:600 which could be reduced to 1:300  3) There are 100 ounces in the solution and the ratio of chemical to solution is 35:100 which could be reduced to 7:20

**Worksheet 5-1**

Name:

Date:

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Express the following as ratios reduced to lowest terms.

1) 1 to 5
2) 2 to 11
3) 2 grams to 9 grams
4) 15 cm to 23 cm
5) 3 feet to 27 feet
6) 25 liters to 5 liters
7) 36 cm to 6 cm
8) 24 inches to 9 inches
9) 3 meters to 9 meters
10) 100 g to 1,000 g

Solve the following problems.

11) If 3 oz of boric-acid solution are added to 897 oz of water, how many ounces are in the total solution? What is the ratio of ounces of boric acid to ounces of solution?

12) If 30 oz of a chemical are combined with 60 oz of water, what is the ratio of chemical to ounces of solution?

13) If 20 oz of alcohol are added to 40 oz of water, how many ounces are in the total solution? What is the ratio of ounces of alcohol to ounces of total solution?

14) If 10 grams of salt are added to 40 grams of water, what is the total weight of the water-and-salt solution? What is the ratio of grams of salt to grams of solution? (*Ordinarily, you would not measure water by mass, but it is possible to do and therefore the problem could be reproduced.*)

15) If 3 mL of glycerin are added to 87 mL of water, what is the ratio of the mL of glycerin to the mL of solution?

16) If 2 grams of a drug are added to 38 grams of petrolatum, what is the ratio of the grams of drug to the grams of the mixture?

17) If 5 oz of a drug are added to 95 oz of water, how many ounces are in the total solution? What is the ratio of ounces of drug to ounces of solution?

**Worksheet 5-2**

Name:

Date:

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Express the following as ratios reduced to lowest terms.

1) 1 to 4
2) 3 to 17
3) 3 grams to 15 grams
4) 2 cm to 7 cm
5) 5 feet to 19 feet
6) 23 liters to 25 liters
7) 3 cm to 18 cm
8) 35 inches to 7 inches
9) 1,000 m to 10 m
10) 12 grams to 48 grams

Solve the following problems.

11) To perform a test, a lab technician adds 5 oz of a test liquid to 395 oz of water. How many ounces are in the solution? What is the ratio of ounces of test liquid to ounces of solution?

12) If 2 oz of chemical are combined with 8 oz of water, how many ounces are in the total solution? What is the ratio of ounces of chemical to ounces of solution?

13) A marathon runner has a normal heart rate of 68 beats/min. After completing a marathon, her heart rate is 110 beats/min. Express the ratio of her normal heart rate to her heart rate after a marathon.

14) If 3 oz of boric-acid[1] solution are added to 741 oz of water, how many ounces are in the total solution? What is the ratio of boric acid to ounces of solution?

15) In 1964, the U.S. Public Health Service reported that the risk of developing lung cancer is 10 times greater for moderate smokers and 20 times greater for heavy smokers than for nonsmokers. Express ratio of risk of cancer for nonsmokers to moderate smokers to heavy smokers. *(Hint, even if you don't smoke you still have a chance of developing lung cancer.)*

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1 Since it has been mentioned repeatedly for various problems, you may be asking, “What's boric-acid?”. Boric-acid, also called boracic acid or orthoboric acid, is a mild acid often used as an antiseptic, insecticide, flame retardant, in nuclear power plants to control the fission rate of uranium, and as a precursor of other chemical compounds. It exists in the form of colorless crystals or a white powder and dissolves in water. It has the chemical formula $B(OH)_3$. When occurring as a mineral, it is called sassolite.

**Proportions**

A proportion is a statement of equality between two ratios.

***Example:***

$$\frac{1}{2}=\frac{2}{4}$$

This proportion can also be expressed as “1:2 = 2:4” or “1 is to 2 as 2 is to 4”.

***Question:***

What would be two other ways to express the following:

$$\frac{a}{b}=\frac{c}{d}$$

This proportion can also be expressed as “$a$:$b$ = $c$:$d$” or “$a$ is to $b$ as $c$ is to $d$”.

**Solving for a Variable in a Proportion**

You have three options:

1) basic algebra
2) cross multiplying
3) “means” and “extremes”

Let's solve the following equation for $a$ using all three methods

$$\frac{a}{b}=\frac{c}{d}$$

***algebra***

Solving for $a$ using basic algebra. First, we need to isolate $a$, we can do this by multiplying both sides of the equation by $b$. Then you can cancel out the $b$s on the left hand side of the equation, and this will leave you with your final answer.

$$\frac{a}{b}=\frac{c}{d} \Rightarrow \text{Multiply both sides by } b. \Rightarrow \frac{b\times a}{b}=\frac{b\times c}{d} \Rightarrow \text{Now cancel out the } b\text{s on the left.} \Rightarrow \frac{\cancel{b}\times a}{\cancel{b}}=\frac{b\times c}{d} \Rightarrow \text{Your final answer} \Rightarrow \boldsymbol{a=\frac{b\times c}{d}}$$

***cross multiplying***

Solving for *a* using cross multiplication. You can multiply diagonally and set both multiplication problems as equal. Then we will want to isolate the *a* by dividing both sides by *d*. Cancel out the *d*s on the appropriate side and you will be left with the final answer.

$\frac{a}{b}=\frac{c}{d}$ ⇨ Cross multiply ⇨ $\frac{a}{b}\times\frac{c}{d}$ ⇨ $a\times d=b\times c$ ⇨ Divide by *d*. ⇨ $\frac{a\times d}{d}=\frac{b\times c}{d}$ ⇨ Cancel ⇨

$\frac{a\times \cancel{d}}{\cancel{d}}=\frac{b\times c}{d}$ ⇨ Your final answer ⇨ $\boldsymbol{a=\frac{b\times c}{d}}$

***"means" and "extremes"***

Solving for *a* using "means" and "extremes". To do this, you need to rewrite your proportion using colons. Next, you multiply your means (your inside numbers) and set them equal to the value of your extremes (outside numbers) when they are multiplied. Then we will want to isolate the *a* by dividing both sides by *d*. Cancel out the *d*s on the appropriate side and you will be left with the final answer.

$\frac{a}{b}=\frac{c}{d}$ ⇨ Rewrite it using colons ⇨ $a:b=c:d$ ⇨ Multiply your "means" and "extremes" ⇨ $a:b=c:d$ ⇨ $a\times d=b\times c$ ⇨ Divide by *d*.

⇨ $\frac{a\times d}{d}=\frac{b\times c}{d}$ ⇨ Cancel ⇨ $\frac{a\times \cancel{d}}{\cancel{d}}=\frac{b\times c}{d}$ ⇨ Your final answer ⇨ $\boldsymbol{a=\frac{b\times c}{d}}$

Now that you've been shown three different ways to solve for a variable in a ratio proportion, let's try a practice problem. Solve for each of the variables in the statement "W is to X as Y is to Z".

1) The value of *W* is:

2) The value of *X* is:

3) The value of *Y* is:

4) The value of *Z* is:

1) $W=\frac{Z}{X\times Y}$ 2) $X=\frac{W\times Z}{Y}$ 3) $Y=\frac{X}{W\times Z}$ 4) $Z=\frac{W}{X\times Y}$

Solve for the variable in each of the following practice problems.

1) $\frac{3.8L}{14L}=\frac{N}{25L}$

2) $\frac{x}{7.2g}=\frac{3.0g}{2.0g}$

3) $5:N=7:9$

4) $3:4=x:15$

1) 6.8 L  2) 10.8 g  3) 6.4  4) 11.25

**Worksheet 5-3**

Name:

Date:

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Solve the following ratio proportion problems.

1) In the proportion 5:8 = 25:40,
   a) The extremes are _____ and _____.
   b) The means are _____ and _____.

Solve for N in each of these problems.

2) $\frac{2}{3}=\frac{4}{N}$ $N$ = _____

3) $\frac{5}{7}=\frac{15}{N}$ $N$ = _____

4) $\frac{3}{6}=\frac{1}{N}$ $N$ = _____

5) $\frac{5}{10}=\frac{7}{N}$ $N$ = _____

6) $\frac{2}{8}=\frac{3}{N}$ $N$ = _____

7) $\frac{N}{3}=\frac{4}{6}$ $N$ = _____

8) $\frac{N}{8}=\frac{3}{24}$ $N$ = _____

9) $\frac{N}{12}=\frac{5}{6}$ $N$ = _____

10) $\frac{N}{4}=\frac{6}{8}$ $N$ = _____

11) $\frac{N}{5}=\frac{10}{25}$ $N$ = _____

12) $\frac{N}{6}=\frac{10}{12}$ $N$ = _____

13) $\frac{N}{7}=\frac{6}{42}$ $N$ = _____

14) $\frac{N}{15}=\frac{2}{5}$ $N$ = _____

15) $\frac{N}{5}=\frac{4}{10}$ $N$ = _____

16) $\frac{3}{5}=\frac{N}{100}$ $N$ = _____

17) $\frac{125}{1{,}000}=\frac{N}{8}$ $N$ = _____

18) $\frac{3}{8}=\frac{375}{N}$ $N$ = _____

19) $\frac{2}{3}=\frac{N}{12}$ $N$ = _____

**Worksheet 5-4**

Name:

Date:

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Write the following problems in fractional-equation form.

1) $3:x = 6:7$
2) $5:8 = N:10$
3) $K:8 = 4:16$
4) $7:9 = 14:N$
5) $2:3 = x:9$
6) $7:N = 14:28$

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Solve the following proportions for $N$.

7) $N:7 = 6:14$
8) $8:10 = 4:N$
9) $3:N = 6:18$
10) $5:8 = N:24$
11) $N:9 = 6:18$
12) $8:N = 16:32$
13) $\frac{2.5}{16} = \frac{N}{8}$
14) $\frac{4.2}{N} = \frac{2.1}{100}$
15) $\frac{6.8}{50} = \frac{13.6}{N}$
16) $\frac{12.0\,g}{4.6\,g} = \frac{8.4\,g}{N}$

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Solve the following word problems.

17) Given a boric-acid solution of 1:400, how many ounces are in 70 oz of the solution?

18) How much magnesium sulfate is needed for a preparation of 24 oz of a 1:4 mixture?

19) The ratio of salt to water in a very concentrated saline solution is 3:8. How much salt should be added to 360 g of water to prepare a solution with this ratio?

20) Given a boric-acid solution of 1:500, how many ounces of boric acid are in 80 oz of solution?

**Worksheet 5-5**

Name:

Date:

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Write the following proportions in fractional-equation form.

1) $4:X = 7:9$
2) $3:5 = N:8$
3) $N:72 = 4.8:12.0$
4) $15.0:N = 31.0:1$
5) $5:17.1 = N:2$
6) $315:32 = N:35$

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Solve the following proportions for $N$.

7) $N:2 = 15:3$
8) $4:5 = 8:N$
9) $5:N = 10:17$
10) $5:9 = N:10$
11) $\frac{3.5}{N} = \frac{70}{100}$
12) $\frac{N}{1.4} = \frac{12}{28}$
13) $\frac{N}{2.2} = \frac{1.7}{1}$
14) $\frac{14.0\,g}{70\,mL} = \frac{12.0\,g}{N}$
15) $\frac{2.1\,L}{8\,L} = \frac{N}{12.0\,L}$
16) $\frac{14.1\,oz}{5.8\,oz} = \frac{4\,oz}{N}$
17) $\frac{N}{\$712} = \frac{\$0.07}{\$1.00}$

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Solve the following word problem.

18) Given a colloidal suspension of 3.5:100, how many mL of colloids are present in 946 mL of this colloidal suspension?

**Dimensional Analysis** *(a.k.a., Factor Label Method)*

Dimensional analysis is a conceptual tool often utilized in health care to understand physical situations involving a mix of different kinds of physical quantities. It is routinely used by pharmacists and pharmacy technicians to calculate things such as weight, volume, dose, dosage form, and time. To solve a problem using dimensional analysis, you need to first identify what information is provided by the problem as well as any conversion factors that you will need to solve the problem. Terms that are equal to each other may be written in the form of a fraction.

If 1 capsule is 250 mg you could say that 1 capsule = 250 mg. To write that as a fraction you could write:

$$\frac{1\,capsule}{250\,mg} \quad \text{or} \quad \frac{250\,mg}{1\,capsule}$$

***Example:***

How many tablets will be taken in seven days if a prescription order reads zafirlukast 20mg/tablet, one tablet twice a day?

QUESTION:
How many tablets?
DATA:
7 days 20mg/tablet
1 tablet/dose 2 doses/day
MATHEMATICAL METHOD / FORMULA:
Dimensional Analysis
DO THE MATH

$$\frac{7\,days}{1}\times\frac{2\,doses}{day}\times\frac{1\,tablet}{dose}$$

cancel out dimensions where applicable

$$\frac{7\,\cancel{days}}{1}\times\frac{2\,\cancel{doses}}{\cancel{day}}\times\frac{1\,tablet}{\cancel{dose}}=\mathbf{14}\,\boldsymbol{tablets}$$

DOES THE ANSWER MAKE SENSE ?
Yes

Notice in the above example how dimensions are used to cancel everything out until you are left with just what you need, in this case tablets.

**5 Step Method**

You may also notice the way the example was broken down with five questions. This is known as the “5 Step Method”. The “5 Step Method” is simply a way to help you interpret the data in a problem and get the answer. While certainly the problems in this book can be solved without using the “5 Step Method”, you will find that many example problems throughout the book are broken down this way.

The five steps are: 1) QUESTION (identify what the question is asking); 2) DATA (identify the data in the problem and any necessary conversion factors); 3) MATHEMATICAL METHOD/FORMULA (identify the method or formula needed to solve the problem), 4) DO THE MATH (exactly what the statement says), and 5) DOES THE ANSWER MAKE SENSE? (sometimes an answer will not make sense, and that may mean that there is an error).

Now we should try a practice problem using dimensional analysis and the “5 Step Method”.

How many tablets will you need to provide a 24 hour supply of metoprolol succinate 50 mg/dose 1 dose/day if you have 25 mg tablets available.

QUESTION

DATA

MATHEMATICAL METHOD / FORMULA

DO THE MATH

DOES THE ANSWER MAKE SENSE

2 tablets

**Worksheet 5-6**

Name:

Date:

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Solve the following problems using dimensional analysis.

1) How many tablets will be taken in three days if a prescription reads zafirlukast 20 mg/tablet, one tablet twice a day?

2) How many capsules will be taken in seven days if a prescription order reads tetracycline 250 mg/capsule, one capsule four times a day?

3) How many tablets will be taken in four days if a prescription order reads sucralfate 1 g/tablet, one tablet four times a day?

4) How many tablets will be taken in 10 days if a prescription order reads warfarin 5 mg/tablet, one tablet daily at bedtime?

5) How many tablets will be taken in 30 days if a prescription order reads metoprolol tartrate 50 mg/tablet, one tablet two times a day?

6) How many tablets will be taken in two days if a prescription reads famotidine 20 mg/tablet, one tablet three times a day before meals?

7) How many tablets are needed to fill a prescription for 34 days for albuterol 2 mg/tablet four times a day?

8) How many capsules are needed to fill a 4 week supply of fluoxetine HCl controlled release 60 mg/capsule, one capsule every week?

9) How many tablets are needed to fill a prescription for 21 days for repaglinide 0.5 mg/tablet, one tablet three times a day?

10) How many tablets are needed to fill a 72 hour supply for dipyridamole 50 mg/tablet, one tablet four times a day?

**Worksheet 5-7**

Name:

Date:

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Solve the following problems using dimensional analysis.

1) How many tablets will be taken in seven days if a prescription order reads furosemide 20 mg/tablet, one tablet twice a day?

2) How many tablets are needed to fill a prescription for seven days for alprazolam 0.5 mg/tablet, one tablet three times a day?

3) How many tablets are needed to fill a prescription for 90 days for dipyridamole 50 mg/tablet, one tablet four times a day?

4) How many capsules are needed to fill a prescription for 28 days for potassium chloride 10 mEq/capsule, one capsule four times a day?

5) How many tablets are needed to fill a four day prescription of azithromycin 500 mg/tablet, one tablet daily?

6) How many tablets will be taken in 30 days if a prescription order reads methylphenidate 10 mg/tablet, one tablet three times a day?

7) How many capsules are needed to fill a 90 day supply of zidovudine 100 mg/capsule, three capsules twice daily?

8) You receive the following order for 10 mg terazosin HCl capsules:

Rx terazosin HCl 10 mg/capsules
Dispense: 30 day supply
Sig: Take 1 capsule by mouth at bedtime for 3 days,
then take 2 capsules by mouth at bedtime for 5 days,
then take 4 capsules by mouth at bedtime thereafter.

How many capsules should you dispense? *(Hint ~ This problem will require several dimensional analysis equations to get your final answer.)*

**Worksheet 5-8**

Name:

Date:

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Solve the following problems using dimensional analysis.

1) How many tablets will be needed to fill a prescription for three days for upsadasium 25 mg/tablet if it is ordered 50 mg of upsadasium three times a day?

2) How many capsules are needed to fill a 30 day prescription for 25 mg/capsule of downagain if it is ordered one capsule every day.

3) How many tablets will be taken in three days if a prescription order reads sucralfate 1 g/tablet, one tablet four time a day?

4) How many tablets will be taken in seven days if a prescription order reads Ambien 5 mg/tablet, one tablet daily at bedtime?

5) How many capsules are needed to fill a prescription for 90 days if a prescription order reads zidovudine 100 mg/capsules, three capsules twice daily?

6) How many capsules are needed to fill a prescription for 14 days for potassium chloride 10 mEq/capsule, one capsule four times a day?

7) How many capsules are needed to fill a prescription for 30 days for prazosin 1 mg/capsule, two capsules three times a day?

8) You dispense a prescription for furosemide 40 mg. The instructions read take one tablet by mouth twice a day for 10 days. What is the total number of tablets you should dispense?

9) An order is received for dexamethasone 10 mg twice a day for 5 days, 5 mg twice a day for 4 days, and 2.5 mg twice a day for 2 days. Your stock is 10 mg tablets scored in fourths. What would be the total amount of tablets for you to dispense? *(Hint ~ This problem will require several dimensional analysis equations to get your final answer.)*

**Worksheet 5-9**

Name:

Date:

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Express the following as ratios reduced to lowest terms.

1) 1 to 9
2) 2 g to 12 g
3) 6 cm to 36 cm

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Solve the following word problems.

4) What is the ratio of chemical to ounces of solution if 20 oz of chemical are combined with 80 oz of water?

5) How many ml of a drug are needed to prepare 2,500 ml of a 1:20 solution?

6) How much hydrocortisone is needed to prepare a 120 grams of a 1:50 ointment?

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Write the following proportions in fractional-equation form.

7) 5:$x$ = 10:15
8) 6:11 = $Y$:12
9) 1:3 = $N$:18

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Solve the following ratio proportions for $N$.

10) $N$:10 = 3:5

11) $N$:10 = 4:5

12) $N$:9 = 2:3

13) $\frac{3.1\,g}{15.5\,g} = \frac{8.1\,g}{N}$

14) $\frac{4.2\,g}{16.8\,g} = \frac{7.1\,g}{N}$

15) $\frac{4.1\,g}{12.3\,g} = \frac{6.1\,g}{N}$

16) $\frac{4.4\,mL}{17.6\,mL} = \frac{N}{4\,mL}$

17) $\frac{5\,in.}{12\,in.} = \frac{N}{8\,in.}$

18) $\frac{50\,g}{100\,mL} = \frac{N}{4\,mL}$

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Solve the following problems using dimensional analysis.

19) How many tablets will be taken in seven days if a prescription order reads zafirlukast 20 mg/tablet, one tablet twice a day?

20) How many tablets are needed to fill a prescription for seven days for cyproheptadine 4 mg/tablet, one tablet three times a day?

21) How many tablets are needed to fill a prescription for 30 days for dipyridamole 50 mg/tablet, one tablet four times a day?

22) How many capsules are needed to fill a prescription for 14 days for potassium chloride 10 mEq/capsule, one capsule four times a day?

23) How many capsules are needed to fill a 14 day prescription of ampicillin 500 mg/capsule, one capsule four times a day?

24) How many tablets will be taken in 90 days if a prescription order reads atomoxetine 10 mg/capsules, one capsule three times a day?

25) How many capsules are needed to fill a three day supply of zidovudine 100 mg/capsule, three capsules twice daily?

26) How many tablets will be taken in two days if a prescription order reads promethazine 12.5 mg/tablet, one tablet three times a day?

27) Each tablet of TYLENOL WITH CODEINE contains 30 mg of codeine phosphate and 300 mg of acetaminophen. By taking two tablets daily for a week, how many milligrams of each drug would the patient take?

28) The biotechnology drug filgrastim (NEUPOGEN) is available in vials containing 480 micrograms (mcg) of filgrastim per 0.8 mL. How many micrograms of the drug would be administered by each 0.5 mL injection?