MODULE 2

INTRODUCTION TO THE METRIC SYSTEM

Introduction to the Metric System

OBJECTIVES:

1. Given a weight unit expressed in the metric system,convert that unit into another specified metric weight unit.

2. Given a volume unit expressed in the metric system, convert that unit into another specified metric volume unit.

The metric system of measure is the primary system of measurement used in the practice of nursing anesthesia. Although the metric system appears confusing to most laymen, individuals who frequently use the metric system are quick to recognize the accuracy and the ease of calculation associated with this system. This module will be a basic review on the metric system for many of you. Others who have had little exposure to this system may find the material new and challenging. In either event, complete the entire module, the remaining calculations modules require that you have the ability to perform the manipulations discussed in this module.

The first topic of discussion will be the basic units of measure used in the Metric System. The basic units are as follows:

BASIC UNIT	ABBREVIATION	MEASURES
gram	g.	weight
liter	l.	volume
meter	m.	length

In working with parenteral products, you will be primarily using the weight (gram) and the volume (liter) units in your calculations.

As a preparer of sterile products, you will be primarily using the weight and volume units of the metric system in your calculations. In addition; most of the drugs you will give are based on the patients weight in kilograms.

Fill in the appropriate blanks:

BASIC UNIT	ABBREVIATION	MEASURES
_____	g.	weight
_____	l.	volume
_____	m.	length

ANSWERS: g.
l.
m.

In daily life, one constantly comes into contact with many prefixes. These "prefixes" are attached to the beginning of "root" words. When placed before a "root" word, the prefix changes the meaning of that "root" word. Below are some examples on how prefixes can modify or change the meaning of the base "root" word.

PREFIX	"ROOT" WORD	NEW WORD
under	ground	underground
mal	adjusted	maladjusted
un	interesting	uninteresting

Prefixes are also very useful in the metric system. There are two sets of prefixes; one set of prefixes will enlarge the basic unit they precede, while the other set of prefixes will decrease the basic unit they precede.

Immediately below is the list of prefixes which will enlarge the basic unit they precede (these prefixes indicate multiplication):

DEKA = 10 times the basic unit

HECTO = 100 times the basic unit

KILO = 1000 times the basic unit

NOTE: In pharmaceutical calculations, the prefix "KILO" will be the prefix most frequently used from the group of prefixes above.

In order to reduce the basic units (indicating division) the following prefixes are used:

PREFIX
deci 1/10 (0.1) of the basic unit
centi 1/100 (0.01) of the basic unit
milli 1/1,000 (0.001) of the basic unit
micro 1/1,000,000 (0.000001) of the basic unit

NOTE: In pharmaceutical calculations, the prefix MILLI will be the prefix used most frequently from the group of prefixes listed above.

Indicate the number which corresponds to the following prefixes.

a. kilo_____ b. milli_____ c. deka_____

d. centi_____ e. micro_____

ANSWERS:	a. 1000	b. 1/1000 (0.001)	c. 10
	d. 1/100 (0.01)		e. 1/1,000,000 (0.000001)

You have received the basic units of the metric system of measure and you have seen how prefixes may be used to modify their quantities. Now let us take a closer look at these basic units of the metric system, the liter and the gram.

The first basic unit with which we shall deal is the liter. The liter is used to measure the volume of substances. As a preparer of sterile products, you will be concerned with the volume measurement of many sterile solutions. For example, patients are often administered a liter of Dextrose 5% in Water.

Therefore, the basic unit of measure which is used to measure the volume of solutions is the liter. A liter is roughly equal to one quart. In some cases, as with syringe orders, a patient must be administered a volume of solution which is less than a liter.

In circumstances where less than a liter of solution is administered, a prefix which has been discussed earlier will aid us in expressing these amounts. The prefix "milli" has been discussed previously, remember: milli indicates that the basic unit it precedes has been divided into 1000 units.

The term milliliter is used to denote 1/1000 of a liter. Saying it nother way, there are 1,000 milliliters in a liter.

1 milliliter (ml.) = 0.001 liter (l.)

-or-

1000 milliliters = 1 liter

NOTE: A milliliter (ml) may be used interchangeably with a cubic centimeter (cc) to denote metric volumes.

Therefore, the basic unit of volume measure used in the metric system is the_____. To denote amounts of fluid less than a liter, the term_____is used. One liter contains_____milliliters.

The other basic unit of metric system measure with which you will be concerned is the gram. The gram is used to measure weight. The weight of most drugs is expressed using the gram. For example, a patient might be given one gram of Sodium Cefazolin (Ancef) for injection.

Since most patients receive less than a full gram of drug at one administration, the prefix "milli" can be used to help us express these amounts of drugs which are less than a gram. You will recognize the term milligram.

1 milligram (mg) = 0.001 gram (g)
or
1000 milligrams = 1 gram

The prefix "kilo" is sometimes used to express large amounts (weights) of substances. "Kilo" means 1000 times the basic unit it precedes.

1 kilogram(kg) = 1000 grams

As a review, the basic unit of weight measure in the metric

system is the_____.

ANSWERS: The basic unit of weight measure in the metric system is the gram

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One (1) gram is equal to _____ milligrams.

ANSWERS: One (1) gram is equal to 1000 milligrams.

One (1) kilogram is equal to _____ grams.

ANSWERS: One (1) kilogram is equal to 1000 grams.

You have just had a brief review of the metric system and some of the terminology associated with it. This knowledge will greatly aid you when you begin to work problems using the metric system. The next major area within the metric system we shall approach is the conversion of one metric unit into another. For example, a certain medication contains 0.332 gram of potassium. This 0.332 gram of potassium would be equal to 332 milligrams of potassium.

Knowing how to convert within the metric system will greatly increase the speed and accuracy of your calculations.

At this time, conversions within the metric system will be discussed.

Conversions within the metric system involve the following:

a. Converting milligrams into grams.
b. Converting grams into milligrams.
c. Converting milliliters (or cubic centimeters) into liters.
d. Converting liters into milliliters (or cubic centimeters).

Note that grams cannot be converted (or expressed) in liters. Remember that the gram is the basic unit of weight, while the liter is the basic unit of volume in the metric system. Likewise, a liter cannot be expressed in grams. This all goes back to density (the mass per unit volume of a substance). An analogy might be that two blocks, one block of lead and the other of paper, would not weigh the same.

Two methods will be discussed on how one may convert within the metric system. Either method may be used; in the final analysis, each method will give the same correct answer.

First, the conversion of a smaller metric unit (like a milligram) into a larger metric unit (like a gram) will be discussed.

For each of these two methods, the following example will be used:

Convert, 750 milligrams into grams

In Method One, the conversion between milligrams and grams must be remembered.

REMEMBER: 1,000 milligrams = 1 gram

Method One uses ratio and proportion principles. Therefore, the "IF-THEN" way of solving the conversion.

STEP 1: Use the conversion as your "IF" ratio:

$$\text{IF} \quad \frac{1{,}000 \text{ milligrams}}{1 \text{ gram}}$$

STEP 2: Write the unknown (X) in the "THEN" statement:

$$\text{THEN} \quad \frac{750 \text{ milligrams}}{\text{“X” gram}}$$

STEP 3: Set up the ratio and proportion statement:

$$\text{IF} \quad \frac{1{,}000 \text{ milligrams}}{1 \text{ gram}} = \text{THEN} \quad \frac{750 \text{ milligrams}}{\text{“X” gram}}$$

STEP 4: Cross multiply:

$$(1{,}000)(X) = (1)(750)$$
$$1{,}000\,X = 750$$

STEP 5: Solve for “x”:

NOTE: Divide each side of the equation by 1,000

$$\frac{1{,}000\text{“X”}}{1000} = \frac{750}{1000}$$

$$\text{“x”} = 0.75 \text{ gram}$$

Therefore, ratio and proportion principles have been used to convert 750 milligrams into 0.75 gram.

PROBLEM:

Convert 300 milligrams into grams.

STEP 1: Use the conversion as your "IF" ratio:

"IF"_____

ANSWERS: “IF” $\frac{1000 \text{ milligrams}}{1 \text{ gram}}$

STEP 2: Write the unknown (X) in the "THEN" statement:

"THEN"_____

STEP 3: Set up the ratio and proportion statement

"IF" _____ = THEN" _____

ANSWERS: "IF" 1000 milligrams / 1 gram = "THEN" 300 milligrams / "x" gram

STEP 4: Cross multiply:

IF $\frac{1{,}000\text{mg}}{1\text{ gram}}$ = THEN $\frac{300\text{ milligram}}{X\text{ gram}}$

ANSWER: IF $\frac{1{,}000\text{mg}}{1\text{ gram}}$ = THEN $\frac{300\text{ milligram}}{X\text{ gram}}$ (1000) (X) = (1) (300) 1000X = 300

STEP 5: Solve for "X":

1,000 "x" = 300

ANSWER:	1,000"x" = 300
NOTE: To find the value of "X" each side of the equation must be divided by 1,000.	$\frac{1{,}000\text{"x"}}{1{,}000} = \frac{300}{1{,}000}$ "x" = 0.300 = 0.3 gram

Method One of converting a smaller metric unit into a larger metric unit used the ratio and proportion approach. Method Two involves the manipulation of the decimal point. Using the following example--convert 750 milligrams to grams.

STEP 1: Locate the decimal point in the unit you wish to convert.

7 5 0 . 0 milligrams
↑ ↑ ↑
3 2 1

STEP 2: Move the decimal point three (3) places to the LEFT.

NOTE: The decimal point would be moved three places because 1 gram is 1,000 times larger than a milligram. Thus, to convert 1,000 to 1, the decimal point must be moved three (3) places to the left.

ANSWER:
750 milligrams = 0.75 gram

PROBLEM:
Convert 600 milligrams to grams.

STEP 1: Locate the decimal point in the unit you wish to convert.

600 milligrams = 600.0 milligrams

STEP 2: Move the decimal point three (3) places to the LEFT.

600.0 milligrams = _____ grams

ANSWERS: 0.6 grams

6 0 0 . 0 milligrams = 0.6 grams
↑ ↑ ↑

CONVERT THE FOLLOWING USING EITHER METHOD.

a. 850 mg = X g

b. 1230mg = X g

c. 325ml = X liters

ANSWERS:	a. 0.85 gram b. 1.23 grams c. 0.325 liters

In the preceding pages the conversion of a smaller metric unit into a larger metric unit was discussed. Conversions within the metric system include converting a larger metric unit (like the gram) into a smaller metric (like a milligram).

First, an example using each of the two previously discussed methods will be discussed: Convert 0.75gram into milligrams.

In Method One, the conversion between grams and milligrams must be remembered: 1.0 gram = 1,000 milligrams.

Method One used ratio and proportion principles. Therefore, the "IF-THEN" way of solving the conversion can be used.

STEP 1: Use the conversion as your "IF" ratio:

"IF" $\frac{\text{1 gram}}{\text{1000 milligrams}}$

NOTE: The "IF" statement can also be written as:

"IF" $\frac{\text{1,000 milligrams}}{\text{1 gram}}$

STEP 2: Write the unknown (X) in the"THEN" statement:

"THEN" $\frac{\text{0.75 gram}}{\text{"x" milligrams}}$

STEP 3: Set up the ratio and proportion statement:

"IF" $\frac{\text{1 gram}}{\text{1,000 milligrams}}$ "THEN" $\frac{\text{0.75 gram}}{\text{" X" milligrams}}$

STEP 4: Cross multiply:

$$(1)(X) = (1{,}000)(0.75)$$

$$X = 750$$

$$X = 750 \text{ milligrams}$$

Therefore, 0.75 gram is equal to 750 milligrams

PROBLEM: 1.4 liter is equal to _____ milliliters

STEP 1: Use the conversion factor as your "IF" ratio:

"IF" _____

STEP 2: Write the unknown (X) in the "THEN" statement:

"THEN"_____

STEP 3: Set up the ratio and proportion statement:

"IF"_____ = "THEN"_____

STEP 4: Cross multiply:

SOLUTION:

$$\text{IF } \frac{1 \text{ liter}}{1000 \text{ milliliters}} = \text{THEN } \frac{1.4 \text{ liter}}{X \text{ liters}}$$

$$(1)(X) = (1.4)(1000)$$

$$X = 1400$$

Therefore, 1.4 liters is equal to 1400 milliliters

Method One of converting a larger metric unit into a smaller metric unit used the ratio and proportion approach. method Two involves the manipulation of the decimal point. Using the following example--convert 0.75 gram into milligrams.

STEP 1: Locate the decimal point in the unit you wish to convert:

0.75 gram

STEP 2: Move the decimal point three (3) places to the RIGHT

NOTE: The decimal point would be moved three places because 1 gram is equal to 1,000 milligrams. Thus, a gram is 1,000 times larger than a milligram. To convert a gram to milligrams, the gram would be multiplied by 1,000.

0. 750← = 750 = 750 milligrams
--->

0.75 gram = 750 milligrams

PROBLEM: 1.2 grams = _____ milligrams

STEP 1: Locate the decimal point in the unit you wish to convert:

STEP 2: Move the decimal point three (3) places to the right.

ANSWER: 1.2000←
--->.
1.2 grams = 1,200 milligrams

PROBLEM: 2.1 grams = _____milligrams

SOLUTION:

Method One: Ratio and Proportion

"IF " 1 gram = "THEN" 2.1 grams
1000 milligrams X milligrams

(1) (X) = (1,000) (2.1)

X = 2,100 milligrams

Method Two:

2.1 grams

2. 100←
---> .

2,100 milligrams,

PROBLEM: 0.6 liter = _____ milliliters

SOLUTION:

Method one: Ratio and Proportion

"IF" 1 liter = "THEN" 0.6 liter
1000 milliliters X milliliters

Method Two:

0.6 liter

(1) (x)	=	(1,000) (0.6)	0.600← ---->.
X	=	600	
X	=	600 milliliters	600 milliliters

0.6 liter = 600 milliliters 0.6 liter = 600 milliliters

Convert the following:

1. 0.25 gram = _____ milligrams

2. 1.3 liters = _____ milliliters

3. 0.005 gram = _____ milligrams

4. 0.08 liter = _____ milliliters

5. 5.650 grams = _____ milligrams

6. 3.23 liters = _____ milliliters

7. 0.34 gram = _____ milligrams

ANSWERS: 1. 250 2. 1300 3. 5 4. 80 5. 5,650
6. 3,230 7. 340

Work the following problems:

A patient is to receive 50 milligrams of captopril orally every eight (8) hours. Captopril tablets 25 milligrams of the drug per tablet. How many grams of the drug will the patient receive per day?

SOLUTION:

The patient will receive 50 milligrams of the drug every eight (8) hours [or three (3)] per day (24-hour period of time).

Therefore, the patient receives 50 milligrams 3 times a day

150 milligrams = 0.15 gram of drug per day

A patient in severe pain is given an injection of 75 milligrams of meperidine hydrochloride (Demerol) every four (4) hours around the clock. Meperidine HCL is supplied in a multidose vial labeled 50 mg of meperidine per 1.0 ml. How many milligrams of meperidine will the patient receive in 24 hours?

SOLUTION: Since the patient receives the drug every (4) hours, he receives the drug six (6) times in each 24 hour period of time.

$$\text{IF } \frac{75 \text{ mg}}{1 \text{ dose}} = \text{THEN } \frac{X \text{ mg}}{6 \text{ doses}}$$

$$(X)(1) = (6)(75)$$

$$X = 450$$

X = 450 milligrams of drug per 24 hours

Most aspirin tablets contain approximately 300 mg of aspirin. How many grams of aspirin would a patient receive if he took two tablets every eight (8) hours for 2 days?

SOLUTION: Since the patient takes two tablets every eight (8) hours, he takes a total of 6 aspirin tablets per day for two days. For a total of 12 aspirin tablets.

Thus,

$$\text{IF } \frac{1 \text{ tablet}}{300 \text{ milligrams}} = \text{THEN } \frac{12 \text{ tablets}}{X \text{ milligrams}}$$

$$(1)(X) = (12)(300)$$

X = 3600 milligrams = 3.6 grams/2 days

A certain 20 milliliter vial of sodium chloride solution contains 2.92 grams of sodium chloride. How many milligrams of sodium chloride are contained in each ml of the solution?

SOLUTION: $\frac{\text{2.92 grams (NACl)}}{\text{20 milliliters NaCl Solution}}$ $\frac{\text{2,920 milligrams (NACl)}}{\text{20 milliliters NaCl Solution}}$

IF $\frac{\text{2,920 milligrams}}{\text{20 milliliters NaCl Solution}}$ (NaCl) = THEN $\frac{\text{X milligrams (NaCl)}}{\text{1 milliliter NaCl Solution}}$

$$(2)(X) = (1)(2{,}920)$$

$$20X = 2{,}920$$

$$X = 146$$

X = 146 milligrams of sodium chloride per milliliter of solution

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PROBLEM:
½ Normal Saline Solution contains 4.5 milligrams of sodium chloride per milliliter of solution. How many grams of sodium chloride are contained in 500 milliliters of the solution?

SOLUTION:

4.5 milligrams of sodium chloride are contained in each milliliter of the solution.

Therefore,

IF $\frac{\text{4.5 milligrams (NaCl)}}{\text{1 milliliter NaCl soln}}$ = THEN $\frac{\text{X milligrams (NaCl)}}{\text{500 milliliters NaCl soln}}$

$$(1)\ (X) = (4.5)\ (500)$$

$$X = 2250 \text{ milligrams}$$

X = 2,250 mg = 2.25 grams of sodium chloride in 500 ml

The induction dose of Propofol (Diprivan) is 2.5mg/Kg. Propofol is supplied in 10mg/ml solution. Your patient weighs 70 Kg. How many milliliters of propofol should you give.

SOLUTION:

Total amount of drug to give in mg equals 70 Kg (patients wt.) X 2.5mg (dosage) = 175 mg

$$\frac{10\text{mg}}{1\text{ml}} = \frac{175\text{mg}}{X\text{ ml}}$$

$$(X)\ (10) = (1)\ (175)$$

$$X = \frac{175}{10}$$

X = 17.5 ml of propofol

Your patient's cardiac status is unstable and he must have surgery. You chose to use Etomidate (Amidate) for induction instead of Pentothal. Etomidate comes in 2 mg/ml. Your patient weighs 95 Kg. If the induction dose for anesthesia is 0.1 to 0.4 mg/Kg, what is the dose range for this patient? How many milliliters (range) should the patient receive for induction?

SOLUTION:

INDUCTION DOSE X PT'S WT (Kg) = TOTAL DOSE

0.1 X 95 = 9.5mg minimal
0.4 X 95 = 38mg maximal

Milliliters of solution to give = $\frac{\text{TOTAL DOSE}}{\text{2 mgs in 1 milliliter (solution strengh)}}$

= 9.5/2 to 38/2

= 4.75 ml to 19 ml of solution

You must do a rapid sequence induction and intubation with cricoid pressure on an emergent cesarean section. You have sodium thiopental (Pentothal) for induction. You want to try to limit the dose to 4 mg/Kg to minimize the effects on the fetus. The patient weighs 75 Kgs and Pentothal is supplied in 500 mg syringes (20ml). How many milliliters of Pentothal do you want to give.

SOLUTION: TOTAL DOSE TO GIVE = PT's WT (Kg) X INDUCTION DOSE

DOSE = 75kg X 4 mg/ kg

= 300 mg

DRUG SUPPLIED IN 500mg/ 20ml = 25mg/ ml

IF $\frac{25mg}{1ml}$ = THEN $\frac{300mg}{X\ ml}$

(25) (X) = (1) (300)

$(X) = \frac{300}{25}$

X = 12 milliliters of Pentothal
