I. Prefixes and their values:

a. Micro (mc) [write out microgram]

- i. Millionth
- ii. 1 microgram = 0.000001 gram
- iii. 1 microgram = 0.001 milligram
    1. **1,000 micrograms = 1 milligram** = 0.001 gram
    2. 500 micrograms = 0.5 mg = 0.0005 gram

b. Milli (m)

- i. Thousandth
- ii. 1 milligram = 0.001 gram
    1. **1,000 milligrams = 1 gram**

c. Centi (c)

- i. Hundredth
- ii. 1 centimeter = 0.01 of a meter
    1. 100 centimeters = 1 meter

d. Deci (d)

- i. Tenth
- ii. 1 deciliter = 0.1 Liter
    1. 10 deciliters = 1 Liter

e. Deka (da)

- i. Tens
- ii. 1 dekagram = 10 grams

f. Hecto (h)

- i. Hundreds
- ii. 1 hectogram = 100 grams

g. Kilo (k)

- i. Thousands **ii. 1 kilogram = 1,000 grams**

The prefixes that you will deal with the most in performing medication calculation problems are milli- (milligrams, milliliters), micro- (micrograms), and kilo- (kilograms). The conversions that you will use most often are bolded. Commit these to memory.

II. Rounding

For purposes of rounding your dose, calculate to the next decimal place beyond the figure you are rounding to. For example, to round to the nearest tenth, calculate to the hundredths decimal place. If the last calculated decimal place is 5 or greater, round the decimal place to the left up. To avoid over or under dosing your patient, never round liquid medications to the nearest whole number; use a syringe with the appropriate calibrations to measure an exact dose. **Round to the smallest unit of measure for the device (syringe, medicine cup, etc.) that you are using to measure the dose.** For example, if you are using a syringe calibrated in tenths of a milliliter, round to the nearest tenth of a milliliter. Rounding examples:

To round to the nearest tenth of an mL: 1.53 rounds to 1.5 mL

To round to the nearest hundredth: 16.699 rounds to 16.7 (in science class you would leave the trailing zero, 16.70, to indicate the level of precision; in medical use, omit trailing zeros to avoid error)

Scored tablets can be rounded to the nearest half tablet. 1.8 tablets would round to 2 tablets, 1.4 tablets would round to 1.5 tablets, and 1.2 tablets would round to 1 tablet. Check with a pharmacist to see if the pill is available in a dose strength that would be more accurate than rounding and breaking tablets.

III. Equivalents:

Volume:

Metric		Household		Apothecary
5 mL	**=**	**1 teaspoon (tsp)**	**=**	**1 teaspoon (tsp)**
15 mL	=	1 tablespoon (Tbsp)	=	1 tablespoon (Tbsp)
30 mL	**=**	**2 tablespoons**	**=**	**1 ounce**
240 mL	=	1 measuring cup	=	8 ounces
500 mL	=	1 pint	=	16 ounces
1000 mL	=	1 quart	=	32 ounces

Weight:

Metric		Apothecary
1 kg	**=**	**2.2 lb**
1 gm	=	15 grains (gr xv)
60 mg	**=**	**1 grain (gr i)**
0.6 mg	=	gr 1/100
0.4 mg	=	gr 1/150
0.3 mg	=	gr 1/200

IV. Ratio and Proportion

A ratio can be expressed as a fraction; for example, the ratio 1:4 can be expressed as ¼ and 3:8 can be expressed as ⅜. Similarly, the ratio 5:1 would be written as 5/1.

When you are solving a drug calculation problem using the ratio & proportion method, you are always comparing what you know to what you do not know:

$$\underset{\text{KNOWN}}{\frac{\text{Amount of drug in the vehicle on hand}}{\text{Vehicle on hand (cap, tab, mL)}}} = \underset{\text{UNKNOWN}}{\frac{\text{amount of drug ordered}}{\text{amount of vehicle needed for the ordered dose}}}$$

For example, the doctor orders 750 mg of Amoxicillin and you have a bottle of 250 mg capsules of Amoxicillin on hand. What you know is that there are 250 mg per (or in) one capsule. This can be set up as a ratio of 250 mg : 1 capsule or 250/1. What you do not know is how many capsules you will need to administer to the patient to give 750 mg of the drug. So the unknown is 750 mg per an unknown number of capsules. An unknown quantity is expressed as "X" so the ratio becomes 750 mg : X capsules. To set up a proportion, you would write "250 : 1 :: 750 : X," which is read "250 is to 1 as 750 is to X." When the ratios are converted to fractions, you can write the proportion as an equation:

$$\frac{250\text{mg}}{1\text{ cap}} = \frac{750\text{mg}}{X\text{ cap}}$$ (where X represents the number of capsules needed to make the ordered dose)

You cross multiple and solve the equation for X: 250 x X = 1 x 750 or
250X = 750
if you divide both sides by 250, the equation simplifies to: X = 3 capsules

The important things to remember about setting up a problem utilizing ratio and proportion are:

1. Make sure that the units of measure are the same in the known quantities and the unknown quantities. If they are not, convert the unknown (the order) to what is known (the dose on hand). If for example the order is in grams and the dose on hand is in milligrams, convert the ordered dose to milligrams prior to setting up the proportion.
2. Set the proportion or equation up so that the order of quantity (amount of drug) to vehicle (dose form— whatever it is that contains that quantity of drug) is the same on both sides of the equation. For example, in the previous example the fraction on the left side of the equation is “mg over capsules” and is the same on the right side of the equation.

   Another example: The doctor orders 750 mg of Cephalexin oral suspension. You have Cephalexin suspension on hand and the label reads 125 mg per 5 mL. How much of the suspension would you give?
   Your known is 125 mg per 5 mL, so the amount of drug is 125 mg and the vehicle is 5 mL (because that is what contains the 125 mg). The equation becomes

$$\frac{125\text{ mg}}{5\text{mL}} = \frac{750\text{ mg}}{X\text{ mL}} \longrightarrow$$ 125 x X = 5 x 750
125X = 3750
X = 30 mL

You would give the patient 30 mL to provide 750 mg of Cephalexin

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V. Estimating your answer

Taking a moment to estimate what the correct to a med calc problem answer should be will often save you from making a serious medication administration error. For example, if you estimate that you will be injecting less than 1 mL of an IV med and then calculate that you should give 1.5 mL, it would lead you to question your results and you would then go back and make sure that you set up the problem and performed your math correctly. In this instance, it may also be a good idea to have someone else check your results.

Example: The order is for DrugX, 12 mg I.V. every 6 hours prn pain. The drug comes in a 2 mL prefilled syringe that contains 15 mg. You estimate that your will not be giving the entire 2 mL (that’s more than you need) but you will be giving more than half of the prefilled amount because half of it would only be 7.5 mg. So you expect the answer to your calculations to be between 1.0 and 2 mL.

$\frac{15 \text{ mg}}{2 \text{ mL}} = \frac{12 \text{ mg}}{X \text{ mL}} \rightarrow 15X = 24 \rightarrow X = 1.6 \text{ mL}$ This fits with the estimate that you made, so you can feel confident about your answer.

You can check the result by substituting your answer for the X in the equation and then cross multiplying. If the proportion is accurate, the products will be equal. For example, with the previous problem, you would check it like this:

$\frac{15 \text{ mg}}{2 \text{ mL}} = \frac{12 \text{ mg}}{1.6 \text{mL}}$ Cross multiply: $15 \times 1.6 = 2 \times 12$, $24 = 24$. The products are equal, so the answer is correct

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VI. IV Calculations

A. Calculating Drip Rates

Calculating the drip rate to manually regulate an IV requires two steps:

1. **Calculate the infusion rate of the IV in milliliters per hr (mL/hr)**

   Convert the **total volume** to be infused to mL and then divide by the **number of hours** over which it will infuse. For example: 1,000 mL to infuse over 8 hours

   $$\frac{1{,}000 \text{ mL}}{8 \text{ hr}} = 125 \text{ mL/hr}$$

2. **Calculate the drops per minute (gtt/min) needed to achieve this infusion rate**

   To calculate the gtt/min from the mL/hr, you need to know the drop factor of the IV tubing you are using. This is the number of drops that are required to make one milliliter, and it will vary depending on the tubing you are using; it could be 10, 15, 20, or 60—most blood tubing is 10 gtt/mL and all minidrip (or microdrip) tubing is 60 gtt/mL.

The formula is: $$\frac{\textbf{Infusion Amount (mL) x Drop factor (gtt/mL)}}{\textbf{Infusion time (min)}} = \textbf{gtt/min}$$

(note: the infusion time may not always be one hour (60 minutes); see Example 2 below)

Example 1: The ordered infusion rate is 1L over 12 hours and the drop factor of the tubing is 15 gtt/mL.

Step one: Calculate the hourly infusion rate

$$\frac{1{,}000 \text{ mL}}{12 \text{ hr}} = 83.3 \text{ mL/hr or } 83 \text{ mL/hr (same as } 83 \text{ mL/60 min)}$$

Step two: Calculate gtt/min (infusion amount = 83 mL, drop factor = 15, and infusion time = 60 min)

$$\frac{83 \text{ mL} \times 15 \text{gtt/mL}}{60 \text{ min}} = 20.75 \text{ gtt/min} \rightarrow 21 \text{ gtt/min}$$

For infusions that require less than an hour:

Example 2: You are to infuse Ancef 1 gm in 100 mL NS every 12 hours. Your drug book says that this medication can be infused over 20 min. The drop factor of the tubing is 20.

Step one: You do not need to calculate an infusion rate because it is already given, it will be 100 mL (infusion amount) over 20 min.(infusion time)

Step two: Calculate gtt/min

$$\frac{100 \text{ mL} \times 20 \text{ gtt/mL}}{20 \text{ min}} = 100 \text{ gtt/min}$$

Short cut method: If you know the rate of the infusion in **ml/hr** and the drop factor of the tubing, then:

If the drop factor is:	Divide the infusion rate (mL/hr) by:	
10	6	
15	4	to get the infusion
20	3	rate in gtt/min.
60	1	

For example #2 above, the infusion rate of the Ancef in mL/hr can be calculated using ratio proportion and would be 300mL/hr. With a drop factor of 20, you would divide the 300 by 3 to get a drip rate of 100 gtt/min.

B. Calculating Drug infusion rates by weight

Order: 3mcg/kg/min of Intropin (dopamine HCl) for a new patient with heart failure.

Available: 400 mg Intropin in 500 mL D_5W.

The patient's weight is 242 pounds. What is the flow rate of the IV?

Step 1: Convert the patient's weight to kilograms (because the order is in kg). Use the conversion factor from page one: 1 kg = 2.2 pounds

$$\frac{242 \text{ lb.}}{2.2 \text{ lb/kg}} = 110 \text{ kg} \quad \text{or} \quad \frac{1 \text{ kg}}{2.2 \text{ lbs}} = \frac{X \text{ kg}}{242 \text{ lbs}} \rightarrow 2.2X = 242, \quad X = 110 \text{ kg} \quad \text{(using ratio/proportion)}$$

Step 2: Calculate how much medication the patient should receive in an hour (because your infusion rate will be in mL/hr.)

3 mcg/kg/min x 110 kg x 60 min/hr = 19,800 mcg/hr

Because the drug on hand is in mg, convert this answer to mg → 19.8 mg/hr

Use ratio/proportion to find the infusion rate:

$$\frac{400 \text{ mg}}{500 \text{ mL}} = \frac{19.8 \text{ mg}}{X \text{ mL}} \rightarrow 400X = 9900 \quad X = 24.75 \text{ mL}$$

The infusion rate will be 25 mL/hr.

Note that in a critical care unit, you may have infusion pumps that are capable of delivering infusion rates in tenths of a milliliter. In that situation, you would round your answer to the nearest 0.1 mL (24.8 mL) rather than to the nearest whole mL.

C. Calculating Heparin infusion rates

Order: 1400 units/hr.

Available: 25,000 units of Heparin in 500 mL NS

At what rate will the Heparin be infused?

This problem can be solved by setting up a simple ratio/proportion:

$$\frac{500 \text{ mL}}{25{,}000 \text{ units}} = \frac{X \text{ mL}}{1400 \text{ units}} \rightarrow 25{,}000\,X = 700{,}000 \quad X = 28 \text{ mL}$$

The infusion rate will be 28mL/hr.

D. Formula method

You can use the formula method to solve med calc problems as well. That formula is

$$\mathbf{X = \frac{D}{H} \times V}$$

Where X = the dose you will give (in terms of the vehicle)
D = the ordered dose
H = the dose on hand
V = the vehicle on hand

To use this formula, make sure that

- D and H are in the same unit of measure
- V represents the vehicle (volume) of the drug on hand (1 capsule, 5 mL, etc.)

Taking the problem from C above:

D = 1400 units/hr
H = 25,000 units
V = 500 mL

$$X = \frac{1400\text{u/hr}}{25{,}000\text{u}} \times 500\text{mL} \rightarrow X = \frac{700{,}000}{25{,}000} \rightarrow X = 28 \text{ mL/hr}$$

When you use the formula method (D over H times V), think alphabetical: the letters are in alphabetical order (D over H times V). This will ensure that you set up the problem correctly. If you don't set up the problem correctly, your answer will vary significantly from your estimate and will probably be an extreme value that will tell you immediately that you did something wrong. For example, using the example from V: Estimating your Answer, if you set this up incorrectly, you would obtain the following answer:

$$X = \frac{15 \text{ mg}}{12 \text{ mg}} \times 2 \text{ mL} \quad X = 2.5 \text{ mL} \qquad \left[\, X = \frac{H}{D} \times V \,\right]$$

This would be outside your estimate and would involve giving the patient more than one syringe of medication. Both of these situations should indicate to you that you should question the dose you calculated.

If you set the Heparin problem up incorrectly, your answer would be almost 9000 mL/hr.

Clinical Precautions:

The unit dose is usually the average dose ordered for adults. If your calculation calls for giving the patient more than one or two times the unit dose, double check your calculations and the order and research the reasons for the larger dose—e.g., check your drug book to see if this is a customary dose for this diagnosis. If in doubt, contact the pharmacist and/or the ordering physician.