SCEMSS Medical Mathematics Study Guide

The Silver Cross EMS System entry exam requires strong knowledge and execution of medical math to ensure paramedics are safe and proficient during pharmacological procedures. In order to be prepared for the entry exam, this study guide will cover all required topics.

Paramedics must be prepared for the various situations that will require mathematical computation. They include:

1) Familiarity with the metric system
2) Mass and volume conversions
3) Weight conversions
4) Volume administration calculations
5) Weight-based drug dosage calculations
6) Medication infusion rate calculations
7) Fluid infusion rate calculations

1) All medications use metric weights and volumes. The units of measurement that are used are micrograms (mcg), milligrams, (mg), grams (g), kilograms (kg), milliliters (mL), and liters (L).

2) The paramedic must be familiar with converting units of measurement. This is done by either multiplying or dividing the unit by 1,000. For example, paramedics must know how to convert grams to milligrams.

Example 1: Convert 1g into milligrams $1g = \_\_\_\_ mg$

$$1\cancel{g} * \frac{1000mg}{1\cancel{g}} = 1000mg$$

Since we are converting a ***larger unit into a smaller unit,*** *we need to* ***multiply*** *by 1,000 so that grams cancel each other out, leaving milligrams.*

Example 2: Convert 300mg into grams $300mg = \_\_\_\_ g$

$$300\cancel{mg} * \frac{1g}{1000\cancel{mg}} = 0.3g$$

If we are converting a ***smaller unit into a larger unit****, then it requires* ***dividing*** *by 1,000 so that milligrams cancel, leaving grams.*

The astute professional will notice when converting units, it is as simple as moving the decimal either three points to the left (small unit to large unit) or right (large unit to small unit).

Example 3: Convert 500mL into L $500 = 500{\scriptstyle\blacksquare}0$ *Move the decimal three spots to the left*

$0{\scriptstyle\blacksquare}500 = 0.5L$

Example 4: Convert 3.4kg into g $3.4kg = 3{\scriptstyle\blacksquare}4000g$ *Move the decimal three spots to the right*

$3400{\scriptstyle\blacksquare}0g = 3400g$

3) The paramedics must know how to convert pounds into kilograms.

$$1kg = 2.2lbs$$

Example 5: Convert 200lbs into kilograms

$$200\cancel{lbs} * \frac{1kg}{2.2\cancel{lbs}} = \frac{200kg}{2.2} = 90.9kg = 91kg$$

The astute professional will notice this is the same as just dividing the mass in pounds by 2.2. The difference is the above example (as well as all of the examples in this Study Guide) uses unit notation. This is imperative to make sure your answers for other calculations (seen below) are correct and is highly recommended you perform your math in this manner.

4) In order to deliver the appropriate <u>amount</u> of a medication, the paramedic needs to calculate how much <u>volume</u> he needs to deliver to the patient. To do this, the paramedic needs to understand the formula:

$$Volume = \frac{Dose}{Concentration}$$

If the paramedic knows the weight of the medication the patient must receive (Dose) and the paramedic knows the concentration of the medication is packaged in (Concentration), the paramedic is able to find the Volume that must be drawn from the vial and administered to the patient.

<u>There are numerous shorthand ways to complete the types of equations found in the rest of this Study Guide. The examples below are the most definitive and complete way to solve these problems and does not require the need for multiple formulas. This is only a Study Guide, not a comprehensive lesson in medical mathematics.</u>

Example 6: Medical Control orders you to administer 8mg of Versed to your patient to induce sedation. You pull the vial of Versed and notice it is packaged as 10mg/2mL. How much volume must you draw up and administer to your patient?

$$Volume = ?$$

$$Dose = 8mg$$

$$Concentration = \frac{10mg}{2mL}$$

You now have all the information needed to complete the equation.

$$Volume = \frac{8mg}{\frac{10mg}{2mL}}$$

To simplify the above division equation, we must invoke a simple math concept called, "multiplying by the reciprocal". Dividing a fraction is the same thing as "flipping" the bottom fraction and then multiplying.

$$\frac{8mg}{\frac{10mg}{2mL}} ====> \frac{8\cancel{mg}}{1} * \frac{2mL}{10\cancel{mg}}$$

Notice, how milligrams cancel out and all we are left with is milliliters. Now we KNOW we have the right answer.

$$\frac{8 * 2mL}{10} = \frac{16mL}{10} = 1.6mL$$

You would, therefore, draw up and deliver 1.6mL to your patient.

5) Many medications require the dosage to be based on how much the patient weighs. We call these weight-based medication dosages. The formula:

$$Volume = \frac{Dose}{Concentration}$$

can and should be used in the same manner as the previous example. The only difference is that the Dose is in $\frac{mg}{kg}$ instead of just mg, but the math remains the exact same. **Remember, if the patient's weight is in pounds, it must be converted to kilograms first.**

Example 4: A 7 y/o patient requires 0.02mg/kg of atropine. Your prefilled syringe contains 1mg of atropine in 10mL. The child's mother tells you the patient weights 30kg. How many milligrams (dose) does the child need? How much volume will you administer?

$$Volume = \frac{Dose}{Concentration}$$

$$Volume = ?$$

We don't know the volume. We need to find it

$$Dose = \frac{0.02mg}{\cancel{kg}} * 30\cancel{kg} = 30 * 0.02mg = 0.6mg$$

Here we know the dose but it has to be converted since it is weight-based. We just multiply by the patient's weight to get rid of the kg and end up with just mg. This is the amount of atropine the child needs.

$$Concentration = \frac{1mg}{10mL}$$

The concentration is what is on the vial. It is how the drug is packaged. We were told this in the question.

Now, we apply the whole formula

$$Volume = \frac{Dose}{Concentration}$$

$$Volume = \frac{0.6mg}{\frac{1mg}{10mL}}$$

Multiply by the reciprocal

$$Volume = 0.6\cancel{mg} * \frac{10mL}{1\cancel{mg}}$$

Milligrams cancel out and we're only left with milliliters

$$Volume = \frac{0.6 * 10mL}{1}$$

Reduce

$$Volume = 6mL$$

The paramedic must deliver 6mL to the child to achieve the desired dose.

6) Medication infusion rates

Perhaps the most complex of paramedic medical math problems require the infusion of medications through use of a specifically calculated drip tubing. Even though it may seem more difficult, you can use the same formula we have been using so far and the complexity diminishes.

Example 8: You have just achieved ROSC in a patient who was in cardiac arrest after delivering 300mg of amiodarone. Medical control now orders you to start an infusion of amiodarone at a rate of 10 mg/hour to prevent the patient from devolving back into ventricular fibrillation. You only have 150mg of amiodarone left from your vial. You draw it up and inject it into a 1000ml bag of saline for infusion. What is the rate of infusion (gtt/min) for this patient if you use microdrip tubing?

$$Volume = \frac{Dose}{Concentration}$$

$$Volume = ?$$

$$Dose = \frac{10mg}{hr}$$

$$Concentration = \frac{150mg}{1000ml}$$

Plug your values into the original formula

$$Volume = \frac{\frac{10mg}{hr}}{\frac{150mg}{1000mL}}$$

$$Volume = \frac{10\cancel{mg}}{hr} * \frac{1000mL}{150\cancel{mg}}$$

Multiply by the reciprocal to eliminate the division sign and then reduce

$$Volume = \frac{1000mL}{15hr}$$

Notice how our answer is in mL per hr. That is not what we want. Now we add our tubing size (microdrip is 60 gtt/mL) and convert hours to minutes in one step to get gtt/min

$$Volume = \frac{1000mL}{15hr} * \frac{60gtt}{mL} * \frac{1hr}{60min}$$

$$Volume = \frac{1000\cancel{mL}}{15\cancel{hr}} * \frac{\cancel{60}gtt}{\cancel{mL}} * \frac{1\cancel{hr}}{\cancel{60}min}$$

$$Volume = \frac{1000gtt}{15min}$$

$$Volume = 66.67\ gtt/min$$

7) Fluid infusion rates

Certain situations require the paramedic to deliver a specific amount of fluid in a given amount of time. For example, if a physician orders 1000mL of fluid to be administered in a 240 min period, the paramedic must know how fast he needs to deliver the fluids. **There are a number of formulas to calculate the infusion rate. But we are going to continue to use the same formula expressed in this study guide. It requires a small change in definitions but allows you to use the same formula for <u>any</u> medical math problem.** If we interpret the rate of infusion (drops per minute (gtt/mL)), as the patient's Dose, it allows for easy math. Then, to determine the concentration, we need to know the size of the drip rate tubing (i.e. 10gtt/mL) and the amount of time the fluid is delivered over. The paramedic can then use the same formula to calculate this desired dose.

Example 7: A physician orders 1000mL of fluid to be administered to a patient over four hours (240 minutes). What is the proper drip rate the patient must be given (the dose) if the paramedic uses macrodrip (10gtt/mL) tubing?

$$Volume = \frac{Dose}{Concentration}$$

We need to find Dose, so we need to isolate it and change the formula

$$Volume * Concentration = Dose$$

$$Volume = 1000mL$$

We are told the volume is 1000ml by the physician

$$Concentration = \frac{10gtt/mL}{240mins}$$

The concentration is drip rate divided by the amount of time the infusion is administered over

$$Dose = ?$$

This is what we need to find: the rate of infusion

$$1000\cancel{mL} * \frac{\frac{10gtt}{\cancel{mL}}}{240mins} = Dose$$

Now, just plug in the numbers and do the math

$$\frac{10000gtt}{240mins} = Dose$$

$$Dose = \frac{41.667gtt}{min}$$

You will need to infuse the fluid at a rate of 41.67 drops per minute