IV Flow Rate Calculations

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IV flow rate calculations are required when setting up intravenous (IV) infusion for patients and it is extremely important that pharmacists know how to accurately calculate them.

In this blog post, I first provide a succinct overview of the rationale for using intravenous therapy, what the parts of the infusion set are, how IV fluids are delivered and pertinent information about the drop factor. I then show you using step-by-step solutions how to solve six strategically selected IV flow rate example problems.

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Video Transcription

Hello everyone, Dr. Danquah here and in this tutorial, we will be taking a look at **IV flow rate calculations**. So, one of the things about IV flow rate calculations, is it occurs with relatively high frequency on the NAPLEX board exam. So that is one reason to really be good at it.

But more importantly, as pharmacists, one of the things we get to do is participate in the preparation and administration of institutional as well as home intravenous infusion therapy. So, it's actually really, really important that we know how to perform these rate of flow calculations.

Learning Objectives

So, in this tutorial, we want to accomplish two main things. The first thing is to be able to calculate the rate of infusion if the volume of infusion and the time of infusion are known.

And then the second major goal is to calculate the rate of flow for an IV in drops per minute if the calibration of the IV set is known along with the volume of the infusion and the time of the infusion.

So the way the tutorial is structured is, we will go through a brief overview to give some context and then I'll go ahead and provide carefully selected examples on different types of flow rate calculations and the different approaches that you can use to solve them.

Intravenous (IV) Therapy

If you are already familiar with the concept of infusion therapy, just skip to those examples so that you can have the best use of your time.

So I know some of you are already familiar with intravenous therapy, but for those of us who do not know much about it, I just wanted to provide some brief context so that when we go through the process and the steps of determining rate of flow calculations, you would have a better understanding of what is going on.

You will have a good physical picture and then all the questions that you see would actually make more sense and even the solutions would be easier to understand.

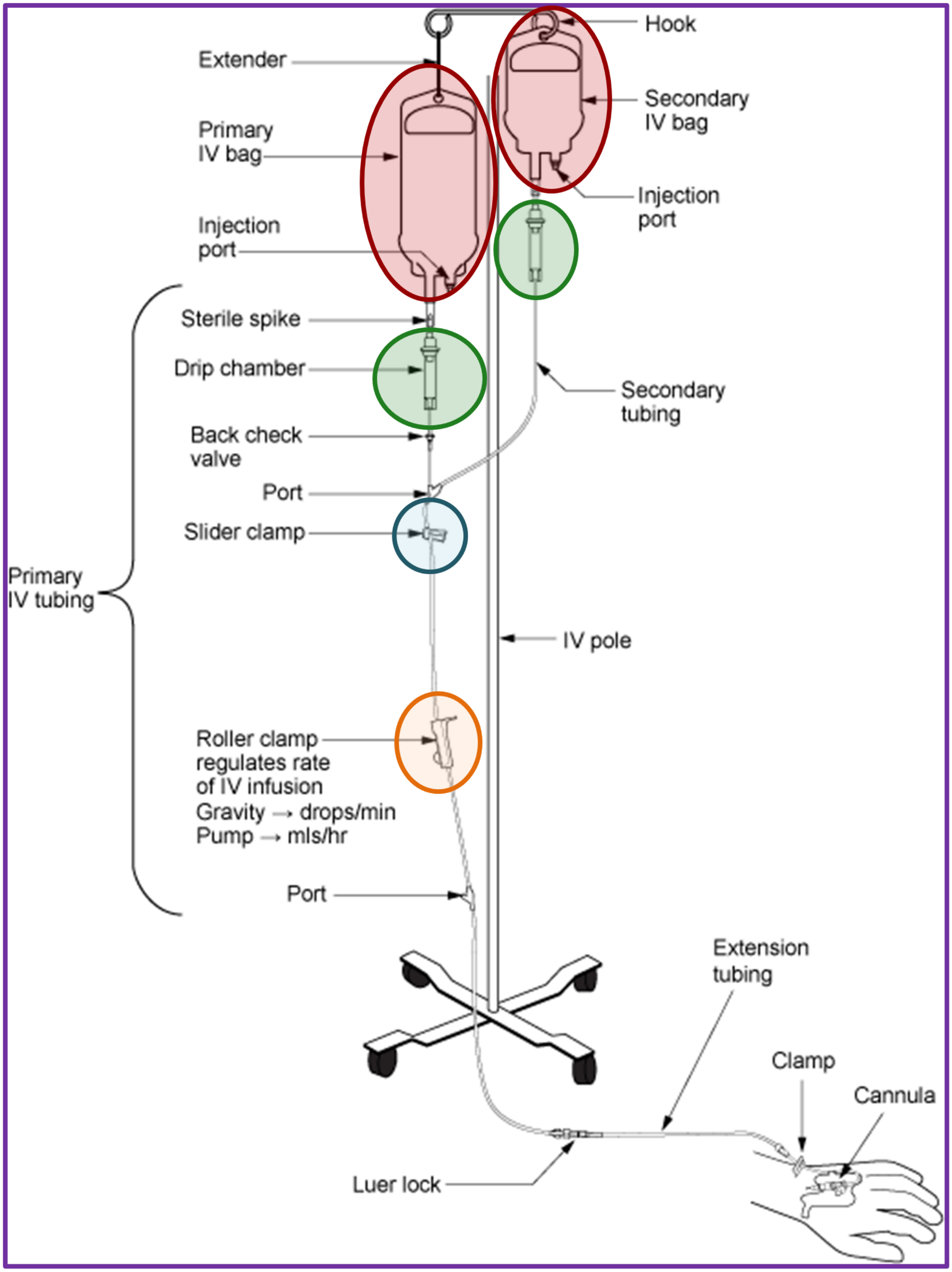
If you walked into an emergency care unit or a hospital, you are more likely to see a patient on a drip.

And one of the reasons why it's such a powerful way to give patients electrolytes, nutrients and medications is because by nature IV's are parenteral preparations so they bypass the G.I. tract, which means that the effect is more immediate and also is 100% bioavailable.

Infusion (Administration) Set

So, to be able to provide the IV therapy to the patient, you need what is known as an infusion or administration set.

Now the infusion set has so many different pieces to it, but for the rate of flow calculations that we're going to be doing. I just wanted to highlight four of the different components which may help us understand the questions better.


Hook
Extender
Secondary IV bag
Primary IV bag
Injection port
Injection port
Sterile spike
Drip chamber
Secondary tubing
Back check valve
Port
Slider clamp
Primary IV tubing
IV pole
Roller clamp regulates rate of IV infusion
Gravity → drops/min
Pump → mls/hr
Port
Extension tubing
Clamp
Cannula
Luer lock

IV Bag

So, the first piece really is the IV bag. The IV bag is what houses the fluid that you are going to be giving to the patient and normally you have a base solution like dextrose 5% or normal saline or lactated ringers injection.

You could also have the base solution with the medication. So, whether it's just a base solution by itself or the base solution together with a medication, all of that will be placed in the IV bag. So that's your receptacle.

Drip Chamber

The next piece of the administration set I want to highlight is the drip chamber. Now the drip chamber lets you know how fast the fluid is actually moving through the tubing into the patient. It gives you an idea of the number of drops in a specified time, normally its number of drops per minute.

The analogy that I normally use is, your drip chamber is analogous to the speedometer of a vehicle which lets you know how fast the car is actually moving.

So, in this scenario, once you have an idea of how fast the fluid is moving through the tubing, you from time to time want to be able to control that flow rate.

Slider Clamp

There are a number of things that will help us do that. The first one is the slider clamp. Now, the slider clamp is a piece of the administration set which basically completely shuts off the flow. So, once you push it in a certain direction, it will basically completely cut off the flow.

Roller Clamp

The other piece is the roller clamp. Now, the roller clamp is such that if you moved it in all the way in one direction, you will have basically the fluid flowing uninhibited with no resistance and if you switch it all the way to the other end it will basically cut off the flow.

So somewhere in between those extremes, you could basically adjust it in such a way that you could have the flow rate that you actually desire. The analogy that I normally use is the roller clamp is analogous to the accelerator pedal in the vehicle.

If you stepped all the way down on the pedal, your car is going to go really fast. And if you took your feet off that pedal it’s going to basically come to a halt. And somewhere in between, you could actually determine the speed at which you want your vehicle to move.

That's similar to what the roller clamp actually does in the administration set. So those are the four things I think will be really helpful as we go through the math in terms of determining flow rate calculations. It gives you a very good physical picture of what is

How Are IV Infusions Delivered?

So, once you actually have your IV preparation in the bag, how do you actually get it into the patient? Because if you just lay the fluid in the bag with the administration set simply on the flat surface, nothing is going to flow.

You always need some kind of a pressure gradient to get the fluid into the patient and there are two ways you can deliver the fluid.

Using Gravity

The first one is by gravity. If you hang the bag at a certain height above the patient, it's going to actually by gravity have enough pressure gradient to push the fluid into the patient.

Typically, the rule of thumb is you want the bag to be at least three feet about the patient's heart, which is more or less the reference point. If you delivered your IV infusion by gravity, normally the units of the flow rate, there will be in drops per minute (gtt/min).

Using an Electronic Volumetric Pump

The other way will be to use an electronic volumetric pump. In this instance, you will basically input the flow rate into the pump and then it will use that mechanical force to basically push the fluid against any internal resistance so that the fluid can get into the patient. In that scenario, normally the flow rate is given as milliliters per hour (mL/h).

Drop (Drip) Factor

Now, the next term or concept that we want to be familiar with is the drop factor. So, the drop factor refers to the size of the IV tubing and this size actually normally is stated on the IV administration package itself. This is important because you have different tubing size which comes pre-calibrated to give you different types of number of drops per milliliter (drops/mL).

There are two main categories. You have the macro drip and the micro drip. So, the macro drip has a larger drop size and they normally come in 10, 15 or 20 drops per milliliter. In contrast, the micro drip has smaller drop size and that comes calibrated in 60 drops per mL.

Now the microdrip, because it has a smaller drop size is typically used for pediatric situations, or when you have a very potent medication like an anti-cancer drug, because then when you do the rounding off, you don't have too much error unlike the larger drop size. So that will make a lot more sense if we come across some examples in our calculations.

How to Calculate IV Flow Rate

Now let's talk about flow rate or infusion rate. To calculate the flow rate, you need two parameters: volume and time. So, the infusion rate or flow rate is basically the volume of a solution or a drug that is administered over a given or specified time.

The units typically are in milliliters per hour (mL/h) and that's normally associated with when you are using an electronic volumetric pump or in drops per minute (gtt/min) when you are using gravity as your tool to get enough pressure differential to allow the fluid to flow into the patient.

One of the things that you really want to be able to do is actually be able to convert from milliliters per hour to drops per minute and vice versa. So that kind of conversion activity should be something that you do with great facility.

Three Common Ways to Calculate IV Flow Rates

So now let's talk about the various ways in which you can calculate the flow rate and there are three ways. The first one is to do ratio and proportion. The second one is to use the formula method. And the third one is to do dimensional analysis.

Now, you could use whichever method you are most comfortable with. But personally, I do recommend that you use the dimensional analysis. It's one of the most powerful ways to basically solve flow rate calculations. And if you know what you are doing, it is almost impossible to get a question wrong.

So, I'll go ahead and demonstrate how you could use ratio proportion and the formula method to solve flow rate calculations. But I will do the remaining of the examples in this tutorial using dimensional analysis just to let you know how powerful it is and how it could always help you get the answer correct all the time. Okay, so let's take a look at an example where we are using ratio and proportion as an approach to determine the flow rate.

1. Ratio and Proportion Approach

Example 1

In this example, it says a patient is to receive an IV of 1 liter of Lactated Ringer’s over 8 hours. The IV set to be used is calibrated at 10 drops per mL. (a) What is the flow rate in mL/h? (b) What is the flow rate in drops per minute?

Example 1a

A patient is to receive an IV of 1 liter of Lactated Ringer's over 8 hours. The IV set to be used is calibrated at 10 drops per mL. (a) What is the flow rate in mL/h? (b) What is the flow rate in drops per minute?

$$\frac{1,000\ mL}{8\ hours} = \frac{X}{1\ hour}$$

$$X = \frac{1,000\ mL\ x\ 1\ hr}{8\ hours} = 125\ \text{mL/h}$$

Let's take a look at the solution to part A of the question. Here, the first thing we want to do is to set up the ratio. So, we take the volume, which is a 1000 milliliters and we divide that by the time, which is eight hours. Whenever you have a flow rate, it's volume per time. So that is why we have the 1000 milliliters divided by the eight hours. That is the ratio.

And now we set up a proportion. Because we want the answer in milliliters per hour, you want to find out what the volume will be when you have just one hour. So, we solve for X. X equals a 1000 milliliters times one hour divided by eight hours, and that basically gives you 125 milliliters per hour. So that's the answer to part A.

Now let's take a look at the answer to part B of the question. Same question. So, we had 125 milliliters per hour and we are moving to drops per minute. That means that we need to convert the hour piece to minutes. And that's where you need the conversion factor of one hour being equal to 60 minutes.

So knowing that, the ratio now becomes 125 milliliters divided by 60 minutes and then we set up a proportion to determine how many milliliters will be required in a single minute because we want to arrive at drops per minute eventually.

We solve for X and X is going to be equal to 125 milliliters times one minute divided by 60 Minutes. And that gives us 2.08 milliliters per minute. But we don't stop here. Our goal is to get to drops per minute.

We need an additional step and using the drop factor, we have 10 drops in one milliliter. And so we set up a proportion to figure out how many drops would be needed for the 2.08 milliliters that we just calculated.

So, we solve for this variable again, which is X and X equals 10 drops times the 2.08 milliliters divided by 1 mL and that gives you 20.8 drops per minute or 21 drops per minute. So this is an example where we used a ratio and proportion approach to determine flow rate.

Example 1b

A patient is to receive an IV of 1 liter of Lactated Ringer's over 8 hours. The IV set to be used is calibrated at 10 drops per mL. (a) What is the flow rate in mL/h? (b) What is the flow rate in drops per minute?

Convert the flow rate to mL/min. 1 hour = 60 minutes

$$\frac{125\ mL}{60\ mins} = \frac{X}{1\ min}$$

$$X = \frac{125\ mL\ x\ 1\ min}{60\ min} = 2.08\ \text{mL/min}$$

$$\frac{10\ drops}{1\ mL} = \frac{X}{2.08\ mL}$$

$$X = \frac{10\ drops\ x\ 2.08\ mL}{1\ mL} = 20.8\ \text{drops/min or 21 drops/min}$$

2. Formula Method

Now let's take a look at how you can use the formula method to determine flow rate as well. The formula is such that your rate of flow, which is in drops per minute, is equal to the volume divided by the time, times the calibration or the drop factor. Okay, so that's the equation that you want to use.

Formula for Calculating IV Flow Rate

Calibration or drop factor (drops per mL)

Volume (mL)

$$\frac{V}{T} \times C = R$$

Time (min)

gtt per min

Example 2

Now let's look at an example. In this particular example, you have an order where you have D5W at 125 milliliters per hour. Your drop factor is 10 drops per mL and you're supposed to calculate the flow rate in drops per minute.

Example 2

A physician orders D_5W IV at 125 mL per hour. The infusion set is calibrated for a drop factor of 10 drops per mL. Calculate IV flow rate in drops per min.

$$\frac{V}{T} \times C = R$$

Conversion factor: 1 hour = 60 min

$$\frac{125\text{ mL}}{60\text{ min}} \times 10\text{ gtt/mL} = \frac{\cancel{125}\text{ mL}}{\underset{6}{\cancel{60}}\text{ min}} \times \frac{\overset{1}{\cancel{10}}\text{ gtt}}{\cancel{1}\text{mL}}$$

$$= 20.8\text{ gtt/min}$$

Use your watch to count drops and adjust roller clamp to deliver 21 drops per min.

So, we start off with the equation. Remember, we need volume divided by time, times the calibration factor. So, because we want to end up in drops per minute and the original order was milliliters per hour, we want to convert the hour piece to minute.

So, you need a conversion factor where one hour is equal to 60 minutes. If we put all those values into the equation, we will end up with 125 divided by 60 minutes, times the drop factor, which is 10 drops per mL. And when you do the math, you end up with 20.8 drops per minute.

Now, mind you, you can't really give the patient 0.8 of a drop. So, we will normally round up in this instance. And so, you would adjust the roller clamp that we talked about earlier in such a way that you have 21 drops in a minute. So, this is an example of how you can use the formula method to determine the flow rate.

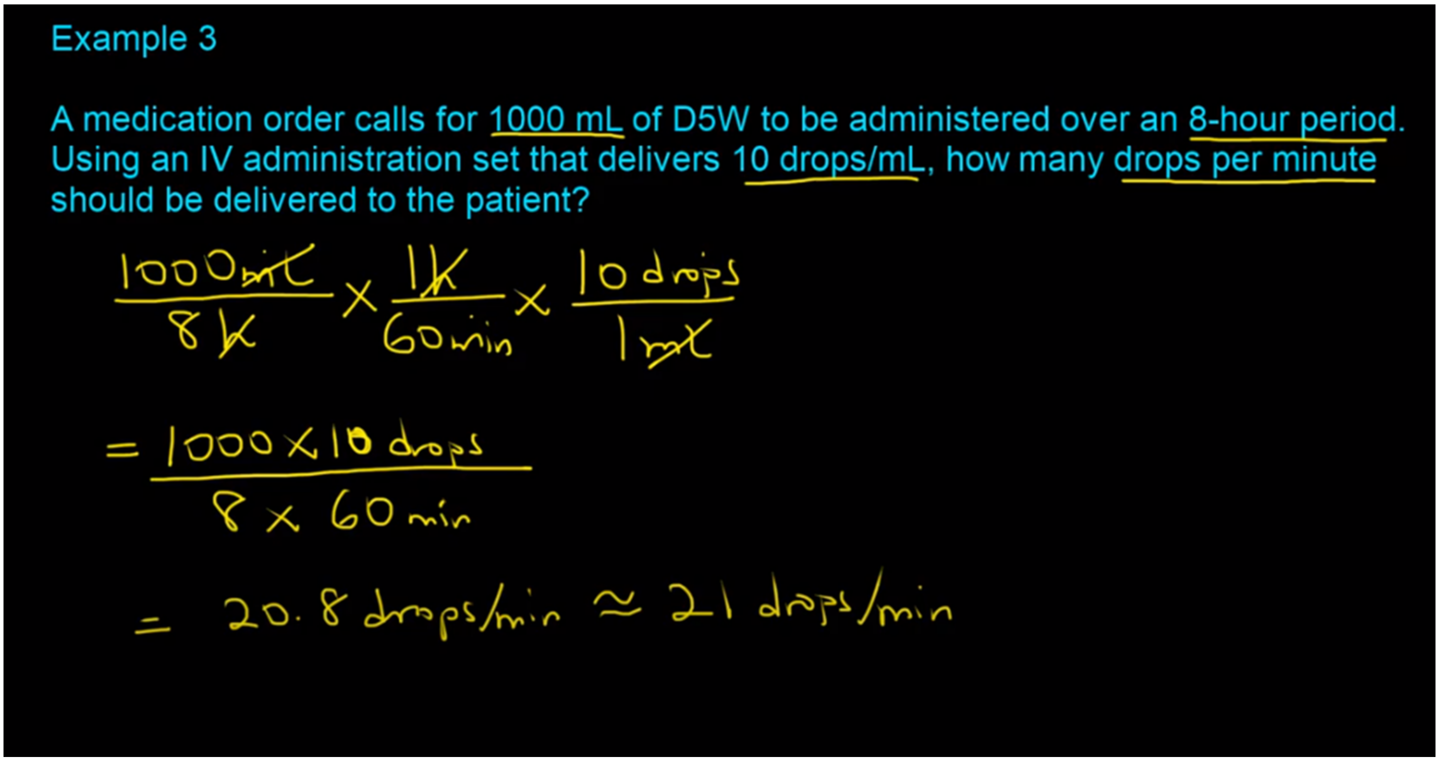
3. Dimensional Analysis Approach

So now let's take a look at how you can use dimensional analysis to determine the flow rate or to do flow rate calculations. And at this point, I'm just going switch screens so that we can have a larger real estate to really explore this approach.

Example 3

So now let's take a look at example 3, which would be our first example using dimensional analysis as a tool to determine the flow rate.

So this question says a medication order calls for 1000 mL of D_5W to be administered over an 8-hour period. Using an IV administration set that delivers 10 drops/mL, how many drops per minute should be delivered to the patient?



Now, this question should look familiar because we used that as our question when we were using the ratio and proportion approach to determine the flow rate.

But here, let's see how the dimensional analysis approach really works? So first of all, we need our volume component, which should be the 1000 milliliters right here, and then we need our time element, which is that eight-hour period.

So, the first thing we'll do is we'll take the 1000 milliliters and we will divide that by the eight hours. So that is basically volume over time, and we want to end up in drops per minute. Which means that eventually the hour term should be converted to minute and the mL should disappear and we should end up with drops.

Now the way we do that, is we take the conversion factor and we will say that since one hour is 60 minutes. We'll put the one hour in the numerator at the top here. And then the 60 minutes in the denominator here.

And we keep track of the units by cancelling out a unit in the numerator with one in the denominator. So, you only cancel out units with one in the numerator, one in the denominator.

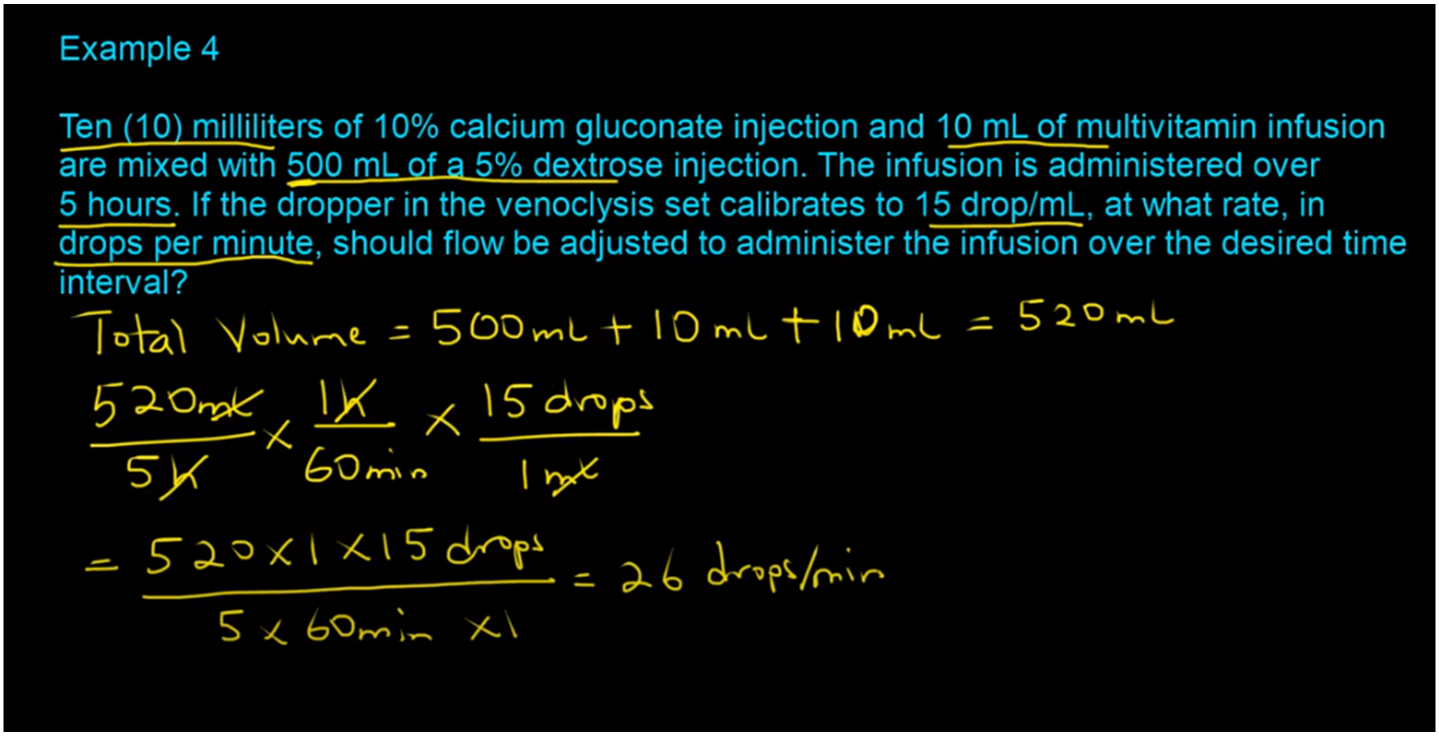
If you look at it carefully, we are now in milliliters per minute. So, we don't stop there. We need some conversion factor that will cancel out the milliliters. That means it has to be in the denominator. And then we need the drops units to be the numerator and we find out that the calibration factor or the drop factor would be a good conversion factor to use here.

So, what we'll do is we'll say we have 10 drops in one mL. The milliliters cancel out and now you are in drops per minute. So, the next thing that we need to do is we need to take every number in the numerator so that will be the 1000 times the 10 drops, and we need to divide that by everything in the denominator. So that will be the eight times the 60 minutes.

So, if you did the math, you end up with a 20.8 drops per minute or approximately 21 drops per minute. So, using this approach and being careful in keeping track of the units, I mean there is almost no way you could get this question wrong once you understand what you're doing.

Example 4

Let's take a look at another example. So, in this question, it says ten (10) milliliters of 10% calcium gluconate injection and 10 mL of multivitamin infusion are mixed with 500 mL of a 5% dextrose injection. The infusion is administered over 5 hours. If the dropper in the venoclysis set calibrates to 15 drop/mL, at what rate, in drops per minute, should flow be adjusted to administer the infusion over the desired time interval?



So here, we want to use the dimensional analysis approach once again. We need to determine what our volume component is to start off with. And so, we have a base solution here, which is 500 milliliters of dextrose 5% injection.

We talked about base solutions earlier and in this particular 500 mL, you are going to be adding 10 milliliters of the multivitamin infusion. But that's not the only thing you are adding, you are also going to add the 10 milliliters of the calcium gluconate as well.

So what that means is your total volume that you are actually going to be giving is going to be equal to that of the base solution, which is the 500 milliliters plus the 10 mL that is coming from the multivitamin plus the 10 milliliters that is coming from the calcium gluconate. So that gives a total of 520 milliliters.

So, this is where, you know, the physical picture that we talked about at the beginning becomes very important. You are adding 10 mL of calcium gluconate and 10 mL of multivitamin into the IV bag. So that's your total volume.

To calculate the flow rate, we need the time component in addition to the volume that we just calculated and the time is given here as five hours.

So, using the dimensional analysis approach, what we will say is we are giving this patient 520 milliliters of fluid over a five hour period and our first task is to get rid of the hour in the denominator. And the way we'll do that is to say that one hour contains 60 minutes.

The hour in the numerator will cancel out the hour and the denominator and we are now essentially in milliliters per minute, but we don't stop there because our ultimate goal is to have the answer in drops per minute.

So, we'll make use of the drop factor, which is 15 drops per mL here. And so, we'll have 15 drops over one milliliter essentially and the milliliters cancel out. And you are basically left with the drops per minute now.

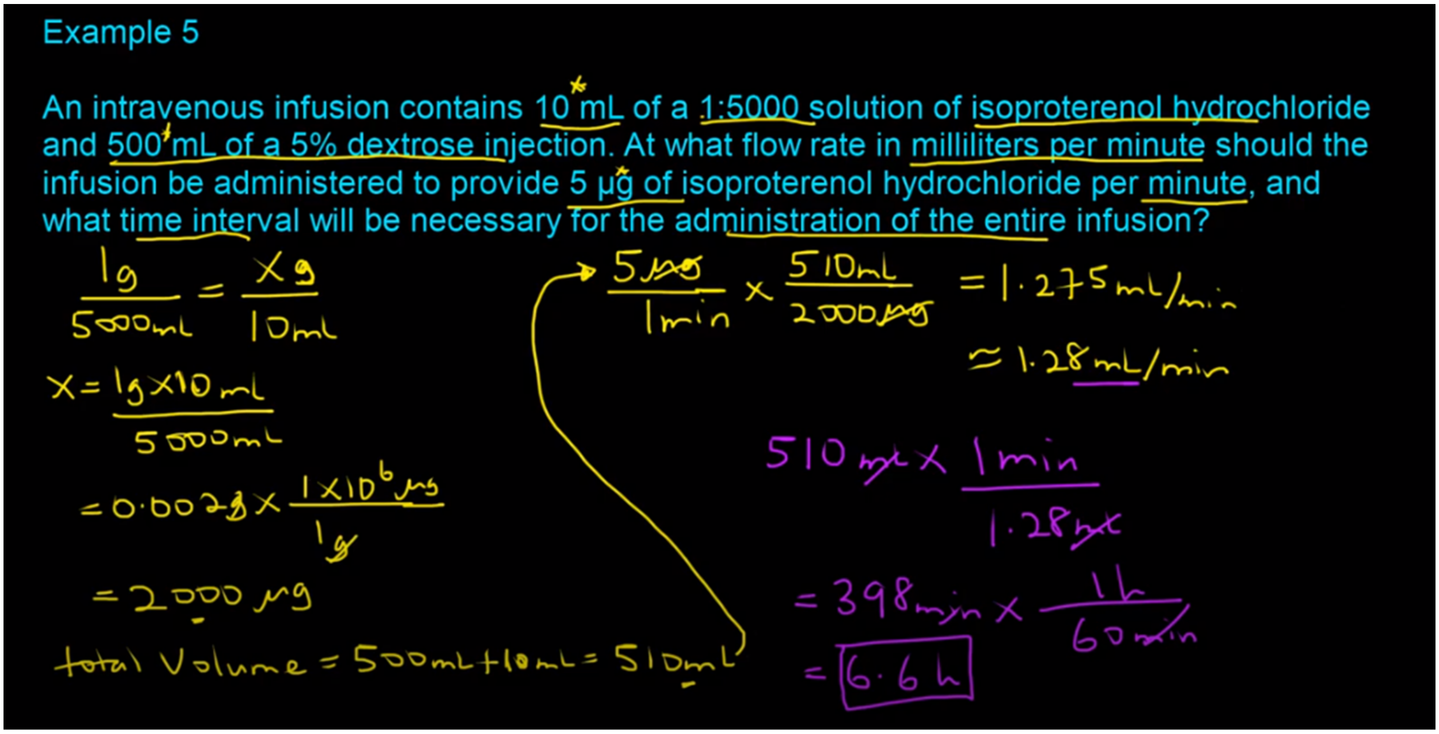
So, the next step will be to take all the numbers in the numerator, we have 520 multiplied by 1 multiplied by 15 drops and then we'll divide that by everything in the denominator. So, we have five times 60 minutes times 1. And so, what we will end up with is 26 drops per minute.

Example 5

Let's take a look at another example. So in this question, it says an intravenous infusion contains 10 mL of a 1:5000 solution of isoproterenol hydrochloride and 500 mL of a 5% dextrose injection. At what flow rate should the infusion be administered to provide 5 µg of isoproterenol hydrochloride per minute, and what time interval will be necessary for the administration of the entire infusion?

So, at first glance, this question looks really complicated. But let's break it down, look at the various elements and see what the best we will be to solve this problem. First of all, take note that the flow rate is actually in milliliters per minute.

Now the first thing we want to do is keep an eye on the rate that has been given. So, we want to restrict the patient to 5 micrograms of isoproterenol hydrochloride in every single minute. But this quantity is a solid quantity and you are giving it as a fluid. So that means we need the volume element, this 5 micrograms is actually flowing in the fluid.



So that's where the ratio strength that has been given and the volume of the container is also necessary. So, what will happen is we will first determine how much isoproterenol in micrograms is present in the 10 mL, which eventually is placed in the 500 milliliters of 5% dextrose injection.

So, let's see what all of that will look like. What that would mean is for 1:5000, we have one gram of isoproterenol HCl in 5000 milliliters of solution. So, we want to figure out how many grams is actually present in the 10 mL. So, we solve for X.

X is going to be equal to 1 gram times 10 milliliters divided by 5000 mL and that ends up giving us 0.002 grams. But it maybe better to convert that to micrograms since the question told us that we are given 5 micrograms so the units are basically consistent.

So, 1 gram contains a million or 1 x 10^6 micrograms. So, the grams cancel out and you are basically left with 2000 micrograms. Now what this means is this 2000 micrograms is actually present in the 10 mL, so when you put this 10 mL into the 500 milliliter solution, the 510 milliliter volume contains 2000 micrograms.

So just to reinforce that, keep note that the total volume here is actually the 500 milliliters plus the 10 milliliters. So that gives you 510 mL.

So, what we want to say here is you actually have the 5 micrograms in one minute. But we want to end up in milliliters per minute, so we need some volume component and some other term in the denominator, which would be micrograms. And so that's where this volume right here and the quantity became pertinent.

What we'll see is we now have our volume, which is 510 mL, but that contains 2000 microgram of isoproterenol. So, the micrograms cancel out and just look at that. You are now in milliliters per minute. So, if you did the math correct you end up with about 1.275 milliliters per minute which rounds up to approximately 1.28 milliliters per minute. So that is the first portion that has be completed.

Now the next piece was what will be the time interval? Time interval that will be needed to administer the entire infusion. So that actually is fairly simple. So what we'll do is we'll take the total volume that we calculated, which is the 510 and then we'll take this flow rate and say that you have one minute and each one minute you have 1.28 milliliters.

So, you see how the dimensional analysis really works nicely so that milliliters cancel out. And basically, what you end up having is 398 minutes. Now we can also convert this to hours, and we'll say that 60 minutes is basically one hour. So, the minutes will also cancel out. And so you end up with 6.6 hours.

So that's how you go about solving this particular problem. Like I said, at first glance it looks really complicated but when you break it down, it's super, super easy.

Example 6

So, let's take a look at another example where we can calculate the flow rate using the dimensional analysis approach, and actually here you have an order.

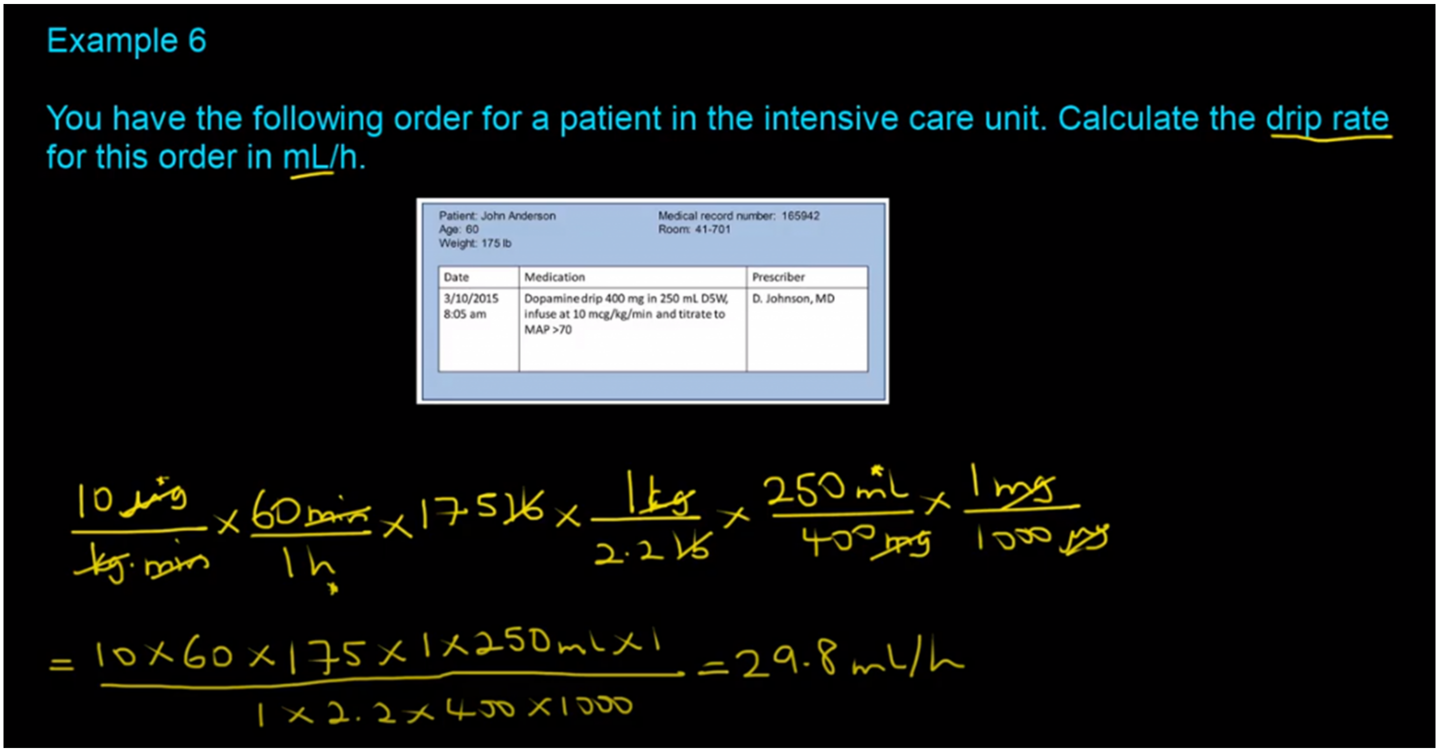
You have the following order for a patient in the intensive care unit. Calculate the drip rate for this order in mL/h.

Patient: John Anderson
Age: 60
Weight: 175 lb

Medical record number: 165942
Room: 41-701

Date	Medication	Prescriber
3/10/2015 8:05 am	Dopamine drip 400 mg in 250 mL D5W, infuse at 10 mcg/kg/min and titrate to MAP >70	D. Johnson, MD

So when you take a look at the order, it tells you that you want to infuse that dopamine at 10 micrograms per kilogram minute. Okay. And so, the first thing we can do, because we want to end up in milliliters per hour is to convert the minutes to hours. So, we say 60 minutes is present in one hour. So, the minutes cancel out and we are now in micrograms per kilogram per hour.



What it means is we need to get rid of basically the kilograms and the way to do that will be to make use of the patient's weight. The patient is 175 pounds, the pounds can't cancel the kilograms out. What we want to do is we want to say that you have 2.2 pounds in one kilogram.

So now the pounds do cancel out and the kilogram here will cancel the kilogram here. So always remember, you need the units to be present both in the numerator and the denominator for it to cancel out.

So, if we keep track of the units where we are right now, we are in micrograms per hour, which means we need some quantity that has both a microgram element and a volume element. And that will be from the dopamine. So, what you want to do next is that the order said here 400 milligrams in 250 mL. So, we will take that 250 milliliters and that will contain 400 milligrams.

So, if you are keeping track of units, we are in microgram milliliters per hour per milligram. But which means we need to convert the milligrams to micrograms. So, we have 1 milligram which contains a 1000 micrograms. The milligrams will cancel out and the micrograms will cancel out. So now you are in milliliters per hour.

So the next thing we do is we take everything in the numerator, which will be the 10 times the 60 times the 175 times the 1 times the 250 mL times the 1 and divide that by everything in the denominator, which would be basically 1 times 2.2 times 400 times 1000. And that should be equal to 29.8 milliliters per hour.

So, I hope this video tutorial helped you have a better understanding of how to do IV flow rate calculations. Now, if you wanted to do more practice, you could head over to rxcalculations.com and then you go to the quizzes, start quiz and you could do some of the questions that are there for more practice.

So, if you enjoyed this video, just hit the like button and I'll be making some more videos on IV flow rate calculations. If you want to be in the loop when those are released, just hit the subscribe button as well.

Do you have any questions or strategies on how to solve IV flow rate calculations? Share them in the comments box below.