Solutions Math

Water Solutions Math: The following are provided as notes for the Solution math presentation.

**Parts Per Million = milligrams per Liter, ppm = mg/L**

We have been using mg/L and % solutions to describe concentrations of solutions for a very long time now. Because there are a million milligrams in one liter of water we also use parts per million to say the same thing.

We even do this when we have some very small concentrations of things such as a part per billion. Since there are a billion micro milligrams in one liter.

With the addition of the Disinfection By-Product Rules to our Water Treatment requirements we refer to the general number of 80ppb (parts per billion) of Total Trihalomethanes as 0.080mg/L or 0.080ppm to say the same thing.
Additionally the MCL for Halo Acetic Acids is 60 ppb (parts per billion) and can be expressed as 0.060mg/L or 0.060ppm. Again a billion is a thousand million or a 1 with 9 zeros = 1,000,000,000. \( \frac{60}{1,000,000,000} = 6 \times 10^{-8} \). \( 6 \times 10^{-8} \times 1,000,000 = 0.060 \) ppm or 0.060mg/L.

**Concentrations can also be Per Cent solutions:**

We will make an imaginary solution called Octorine, that if followed will make a concentrated solution that we can mix down later to a safe drinkable level. Once we do this and then drink it all of the answers to all of the water and wastewater exams will suddenly just flow into your mind (it would be nice).

We start with 14 dry pounds of this powered substance we call Octorine:

Next we get a 55 gallon plastic barrel, put it on a scale and we see that it weighs 60 Lbs. Next we zero the scale and fill the barrel with water. With 55 gallons of water each gallon weighing 8.34 Lbs./Gal the scale now reads 458.7 Lbs. 55 Gals X 8.34 Lbs./Gal = 458.7 Lbs.

We then pour the Dry Powder Octorine, weighing 14 Lbs. into the 55 gallons drum of water and mix it for several minutes. Right after dumping the powder into the tank we see that the barrel now weighs 472.7 Lbs.

We can now calculate the % solution of this Concoction:

\[
\% \text{Solution} = \frac{\text{Dry Weight of the Chemical}}{\text{Weight of the Solution}} \times 100
\]

\[
\% \text{Solution} = \frac{14 \text{ Lbs}}{472.7 \text{ Lbs}} \times 100
\]

\[
\% \text{Solution} = 2.96\%
\]

Look on the Solutions section of the State Formula sheet as shown on page 1-4.

Chapter 1-2
So even at 2.96% of Octorine we have some pretty concentrated stuff. This is because

\[
\frac{10,000 \text{ mg}}{1,000,000 \text{ mg}} = 0.01 \times 100 = 1\%.
\]

So 2.96% × 10,000 ppm/\% = 29,600 ppm of Octorine in that 55 gallons.

Probably too concentrated for us to drink we may want to dilute it down to a smaller amount. We will do that later.
Another important calculation is the specific gravity of the solution. Simply we compare the Weight of the solution to an equivalent weight of water. As per our scale readings earlier, 55 gallons of water weighs 55\text{gals} \times 8.34\text{lbs/gal} = 458.7\text{lbs}.

The solution we made weighs 458.7\text{lbs.} + 14\text{lbs.} = 472.7\text{lbs}.

So: \[
\frac{472.7\text{lbs.}}{458.7\text{lbs.}} = 1.03
\]
Notice that there is no unit label associated with this number. Simply because now all I have to do is multiply 1.03 \times 8.34\text{lbs/gal} (the weight of water) and I will have 8.59\text{lbs/gal} also 472.7\text{lbs/gal} ÷ 55\text{Gals} = 8.59\text{lbs/gal}

Another important method for obtaining the specific gravity of this stuff we made.

Chapter 1-4
Grade 1 and 2 water distribution math problems often focused on the important calculation of gas chlorine which is always at 100% and follows the Lbs. formula. However, dosing a tank or a pipe with gas chlorine is not very practical unless the equipment has already been installed for doing this. More often than not we have to figure how many gallons of this or that we need in the field to do our work for us. Consider the following:

How many gallons of Octorine do I need to dose a million gallon tank to a dose of 1.627ppm?

Find the formula for GPD(gallons per day) on the solution section of the state formula sheet.

\[
GPD = \frac{MGD \times \text{Dose}_{\text{ppm}} \times 8.34_{\text{Lbs/gal}}}{(\%\text{Chemical Purity}) \times (\text{chemical weight of the solution Lbs./gal})}
\]

\%\text{Chemical purity} = \%\text{ solution which we calculated to be 2.96\%}.  
The chemical weight of the solution = (the specific gravity X the weight of water).

So we plug in the numbers:

\[
GPD= \frac{1_{\text{MGD}} \times 1.627_{\text{ppm}} \times 8.34_{\text{Lbs/gal}}}{{(2.967\%)} \times (1.03 \times 8.34_{\text{Lbs./gal}})} \times \frac{100}{100}
\]

\[
GPD= \frac{1_{\text{MGD}} \times 1.627_{\text{ppm}} \times 8.34_{\text{Lbs/gal}}}{{(0.0296)} \times (1.03 \times 8.34_{\text{Lbs./gal}})}
\]

\[
GPD= \frac{13.569_{\text{lbs}}}{0.2542_{\text{lbs./gal}}}
\]

\[
GPD= 53.379_{\text{gallons}} \text{ of Octorine will get me a dose of 1.627 parts per million in a million gallons of water.}
\]

Another way to do this problem is to realize that we can cancel out the 8.34_{\text{Lbs/gal}} in both The numerator and the denominator and get the same answer:

\[
GPD= \frac{1_{\text{MGD}} \times 1.627_{\text{ppm}} \times 8.34_{\text{Lbs/gal}}}{{(0.0296)} \times (1.03 \times 8.34_{\text{Lbs./gal}})}
\]

\[
GPD= \frac{1.627}{0.030488_{\text{Gals}}} = 53.365 \text{ gals.} \text{ Say 54 gallons for both of these approaches.}
\]

Chapter 1-5
As licensed operators you are expected to know how to use both specific gravity and % solution. You should also realize that 1% solution is the same thing as 10,000 mg/L or 10,000 ppm.

Specific Gravity is the calculation we use (if given) to determine the chemical weight in Pounds per gallon (Lbs./gal) of any chemical we are working with.

The % of a chemical in solution is always the Dry weight of the chemical you added to the weight of the water you added it to. For our Octarine calculation:

\[
\text{% Solution} = \frac{14 \text{ Lbs.}}{14 \text{ Lbs.} + 458.7 \text{ Lbs.}}
\]

\[
\text{% Solution} = \frac{14 \text{ Lbs.}}{472.7 \text{ Lbs.}}
\]

\[
\text{% Solution} = 2.967\%
\]

Another problem that might occur on the Grade 3-4 level Water Treatment and Water Distribution tests is the conversion required to adjust a feed rate of a chemical pump.

Using the formula above you should be able to calculate what a chemical pump putting out 141.9 ml/min would equal in Gallons per Day (GPD).

\[
\text{GPD} = \frac{141.9 \text{ ml/min} \times 1,440 \text{ min/day}}{(1,000 \text{ ml/L} \times 3.785 \text{ L/gal})}
\]

\[
\text{GPD} = \frac{204,390 \text{ ml/day}}{3,785 \text{ ml/gal}}
\]

\[
\text{GPD} = 54 \text{ gallons/day.}
\]
Perhaps as important that formula is the one I used to come up with $141.9_{\text{ml/min}}$. Using the Octorine calculations we have been doing. You might want to memorize the following:

\[
\text{ml/min} = \frac{\text{GPD} \times 1,000_{\text{ml/L}} \times 3.785_{\text{L/gal}}}{1,440_{\text{min/day}}}
\]

\[
\text{ml/min} = \frac{54_{\text{GPD}} \times 1,000_{\text{ml/L}} \times 3.785_{\text{L/gal}}}{1,440_{\text{min/day}}}
\]

\[
\text{ml/min} = \frac{54_{\text{GPD}} \times 1,000_{\text{ml/L}} \times 3.785_{\text{L/gal}}}{1,440_{\text{min/day}}}
\]

\[
\text{ml/min} = \frac{204,390_{\text{ml}}}{1,440_{\text{min}}}
\]

\[
\text{ml/min} = 141.9375
\]

Another consideration of solutions and concentrations is what happens when we blend one together with another. As shown before the formula is given as:

\[
C_1V_1 = C_2V_2
\]

Which means if you have a bucket of 10 gallons of a 15% whatever and you mixed it with water in a larger bucket to come up with 50 gallons – the obvious and almost always next question would be what is the concentration of this whatever do you have now. The modified formula for this is:

Two normal equations are not difficult if you remember that you will always be calculating for the next concentration of what you just mixed together.

Chapter 1-7
Another consideration of solutions and concentrations is what happens when we blend one together with another.

As shown before the formula is given as:

\[ C_1 V_1 = C_2 V_2 \]

Which means if you have a bucket of 10 gallons of a 15% solution and you mixed it with water in a larger bucket to come up with 50 gallons – the obvious and almost always next question would be what is the concentration of this whatever do you have now. The modified formula for this is:

\[ C_2 = \frac{C_1 V_1}{V_2} \]

\[ C_2 = \frac{15\% \times 10\text{ gallons}}{50\text{ gallons}} = \frac{150\%}{50} \]

Though it is not on the State formula sheet given the aspect of this formula you will be using the most is:

\[ C_2 = \frac{C_1 V_1}{V_2} \]

With two, three, four and even 5 normal equations the combination of each of the \( C_1 V_1 \) are treated as a bucket that is full with the concentration and therefore is simply multiplied together. Invariably you are almost always solving for what the next result will be when you mix these volumes and concentrations together.

\[ C_1 V_1 = C_2 V_2 \]

\[ C_2 = \frac{C_1 V_1}{V_2} \]

\[ (C_1 V_1) + (C_2 V_2) = C_3 V_3 \]

\[ C_3 = \frac{(C_1 V_1) + (C_2 V_2)}{V_3} \]

And invariably \( V_3 \) is simply \( V_1 + V_2 \)
An operator mixes 3 gallons of a 4.75% solution with 7.0 gallons of a 6.56% solution. Find the new % solution concentration in the mix tank once the two liquids have been mixed together.

\[
(C_2V_2) = (6.56\% \times 7\text{gal.})
\]

\[
(C_1V_1) = (4.75\% \times 3\text{gal.})
\]

\[
\frac{C_3}{V_3} = \frac{(C_1V_1) + (C_2V_2)}{V_3}
\]

\[
C_3 = (4.75\% \times 3\text{gal.}) + (6.56\% \times 7\text{gal.})
\]

\[
C_3 = (14.25\%) + (45.92\%)
\]

\[
10
\]

\[
C_3 = (6.017\%)\)
\]

Chapter 1-9
Similar to considering the volume and % solution in a bucket. We can consider a flow to be a volume as well as a concentration in parts per million. Consider the following:

A city is using water from 3 wells in a well field with nitrite concentrations in them. Well 1 has $9_{\text{ppm}}$ of nitrite and is flowing at $345_{\text{GPM}}$. Well 2 has $16_{\text{ppm}}$ of nitrite and is flowing at $380_{\text{GPM}}$. Well 3 has $4_{\text{ppm}}$ of nitrite and is flowing at $890_{\text{GPM}}$. What is the combined blended flow from these wells and what is the blended concentration of nitrite from this flow?

Again, just as buckets of a solution being mixed together we can consider concentrations in a well at a specific flow rate. A flow rate should be considered a volume as much as a stationary container, like a bucket.

$1,615_{\text{GPM}}$ Flow Rate. $= V_4$

To City Customers @ what concentration of Nitrite in $a$: $345_{\text{GPM}}$ $380_{\text{GPM}}$ $890_{\text{GPM}}$ $\frac{\cancel{345_{\text{GPM}}} + 380_{\text{GPM}} + \cancel{890_{\text{GPM}}}}{V_4 = 1,615_{\text{GPM}}}$
A city is using water from 3 wells in a well field with nitrite concentrations in them. Well 1 has 9 ppm of nitrite and is flowing at 345 GPM. Well 2 has 16 ppm of nitrite and is flowing at 380 GPM. Well 3 has 4 ppm of nitrite and is flowing at 890 GPM. What is the combined blended flow from these wells and what is the blended concentration of nitrite from this flow?

\[
\text{Well 1} \quad \text{Well 2} \quad \text{Well 3} \quad \text{Combined total flow} \\
(C_1 V_1) + (C_2 V_2) + (C_3 V_3) = C_4 V_4
\]

\[C_4 = \frac{(C_1 V_1) + (C_2 V_2) + (C_3 V_3)}{V_4}\]

\[C_4 = \frac{(9 \text{ ppm} \times 345 \text{ GPM}) + (16 \text{ ppm} \times 380 \text{ GPM}) + (4 \text{ ppm} \times 890 \text{ GPM})}{V_4 \text{ GPM}} = \frac{(345 \text{ GPM}) + (380 \text{ GPM}) + (890 \text{ GPM})}{V_4 \text{ GPM}}
\]

\[C_4 = \frac{3,105 \text{ ppm} + 6,080 \text{ ppm} + 3,560 \text{ ppm}}{1,615} = 7.89 \text{ ppm nitrites in a flow of 1,615 GPM}\]
We can even use two normal Equations whenever we need to calculate a dose from something we put into something else:

Going back to our Octorine we can also use the Two and more normal formulas for combing this with other volumes.

Remember that ratio of:
\[
\frac{10,000\text{mg/L}}{1,000,000\text{mg/L}} = 1\%
\]

Remember that 14Lbs. Of Octorine we put into 55 gallons increasing the weight from 458.7Lbs. To 472.7 Lbs. Recalling our \%/ solution
\[
\frac{14\text{Lbs.}}{475.2\text{Lbs.}} = 2.96\% 
\]

\[
2.96\% \times 10,000\text{mg/L} = 29,600\text{mg/L or 29,600ppm}
\]

What would be the concentration in ppm of this 55 gallons of Octorine mixed with 1,000,000 gallons of water?

\[
\begin{align*}
C_1V_1 &= C_2V_2 \\
C_2 &= \frac{C_1V_1}{V_2} \\
C_2 &= 29,600_{\text{ppm}} \times 55_{\text{Gals.}} \\
\frac{C_2}{1,000,055_{\text{Gals.}}} &= 1,628,000_{\text{ppm}} \\
\frac{C_2}{1,000,055} &= 1.6279_{\text{ppm}}
\end{align*}
\]

Chapter 1-12
A classic solutions math problem, involving 12.5% Sodium Hypochlorite is:

A one gallon bottle of 12.5% NaOCl (sodium hypochlorite) is dumped into a tank containing 12,000 gallons of water complete with a mixer. If there is no chlorine demand, what was the resulting residual, in mg/l?

\[ C_2 = \frac{C_1 V_1}{V_2} \]

\[ C_2 = \frac{(12.5\% \times 10,000 \text{ ppm})}{12,001} \]

\[ C_2 = \frac{(125,000 \text{ ppm})}{12,001} \]

\[ C_2 = 10.4157 \text{ ppm} \]

Another simpler classic solution problem involving Sodium Hypochlorite is:

What is the concentration in percent (%) of a solution made by adding 1.0 gallon of 12.5% sodium hypochlorite to 9.0 gallons of water? Again the formula is:

\[ C_2 = \frac{C_1 V_1}{V_2} \]

\[ C_2 = \frac{(12.5\% \times 1 \text{ Gal})}{(9 \text{ Gal} + 1 \text{ Gal})} \]

\[ C_2 = \frac{12.5\%}{10} \]

\[ C_2 = 1.25\% \]
Re doing our original two bucket mixture and the fact that
1% = 10,000 ppm we can re-do our problem considering
the following: 3_gals \times 4.75% can also equal:
\[ 3_{\text{gals}} \times (4.75\% \times 10,000_{\text{ppm/\%}}) \]
\[ 3_{\text{gals}} \times (47,500_{\text{ppm}}) \]
\[ (142,500_{\text{ppm/gal}}) \]
\[ 7_{\text{gals}} \times (6.56\% \times 10,000_{\text{ppm/\%}}) \]
\[ 7_{\text{gals}} \times (65,600_{\text{ppm}}) \]
\[ 459,200_{\text{ppm/gal}} \]

An operator mixes 3 gallons of a 47,500_{\text{ppm}} solution with 7.0
gallons of a 65,600_{\text{ppm}} solution. Find the new mg/L solution
concentration in the mix tank once the two liquids have been
mixed together.

\[ (C_1V_1) = (47,500_{\text{ppm}} \times 3_{\text{gals.}}) \]
\[ (C_2V_2) = (65,600_{\text{ppm}} \times 7_{\text{gals.}}) \]
\[ C_3 = \frac{(C_1V_1) + (C_2V_2)}{V_3} \]
\[ C_3 = \frac{(47,500_{\text{ppm}} \times 3_{\text{gals.}}) + (65,600_{\text{ppm}} \times 7_{\text{gals.}})}{10_{\text{gals.}}} \]
\[ C_3 = \frac{(142,500_{\text{ppm}}) + (459,200_{\text{ppm}})}{10} \]
\[ C_3 = 60,170_{\text{ppm}} \]

\[ C_3 = \frac{60,170_{\text{ppm}}}{10,000_{\text{ppm/\%}}} \]
\[ C_3 = 6.017\% \]
A slight variation on a theme might be:
What per cent concentration is required in a 3 gallon solution that is mixed with 7 gallons of a 6.56% to make 10 gallons of a 6.017% solution?
Here it is the $C_1$ that is unknown, but its volume is given. As well as the final concentration and volume ($C_3V_3$).

\[
(C_1V_1) + (C_2V_2) = (C_3V_3)
\]

\[
C_1 = \frac{(C_3V_3) - (C_2V_2)}{V_1}
\]

\[
C_1 = \frac{(6.017\% \times 10\text{gal}) - (6.56\% \times 7\text{gal})}{3\text{gal}}
\]

Another slight variation on a theme might be:
What per cent concentration is required in a 7 gallon solution that is mixed with 3 gallons of a 4.75% to make 10 gallons of a 6.017% solution?
Here it is the $C_2$ that is unknown, but its volume is given. As well as the final concentration and volume ($C_3V_3$).

\[
(C_1V_1) + (C_2V_2) = (C_3V_3)
\]

\[
C_2 = \frac{(C_3V_3) - (C_1V_1)}{V_2}
\]

\[
C_2 = \frac{(6.017\% \times 10\text{gal}) - (4.75\% \times 3\text{gal})}{7\text{gal}}
\]
Sometimes we have solution problems in which we have a high concentration, mixed with a low concentration, to come up with a fixed final volume or desired concentration. In these problems your goal is to figure out what are the volumes you need of the high concentration mixed with the low concentration to come up with the desired concentration you need for the final fixed volume. Here is an example:

What volumes of an 8% solution and a 3% solution need to be mixed together to obtain 90 liters of a 5% solution? 8% would be the high concentration. 5% would be the desired concentration. 3% would be the low concentration.

Obviously you will need to take a portion of the 90 liters for the high concentration volume and for the low concentration in order to come up with the desired concentration. One way to do this problem is to use the CIA's (Culinary Institute of America's Dilution Rectangle):
RULE 1 OF THE DILUTION RECTANGLE The desired concentration has be more than the Lowest concentration.

We can apply the rectangle to an actual two line formula. where:

\[ C_1 = \text{Highest Concentration} \]
\[ C_2 = \text{Lowest Concentration} \]
\[ C_3 = \text{Desired or final Concentration} \]
\[ V_1 = \text{Volume or flow rate for the highest concentration} \]
\[ V_2 = \text{Volume or flow rate for the lowest concentration} \]
\[ V_3 = \text{Volume or flow rate for the desired concentration} \]

\[ C_1 = \text{Highest Concentration} \quad 8\% \text{Solution} \]
\[ C_2 = \text{Lowest Concentration} \quad 3\% \text{Solution} \]
\[ C_3 = \text{Desired or final Concentration} \quad 5\% \text{Solution} \]
\[ V_1 = \text{Volume or flow rate for the highest concentration} \quad ? \]
\[ V_2 = \text{Volume or flow rate for the lowest concentration} \quad ? \]
\[ V_3 = \text{Volume or flow rate for the desired concentration} \quad 90 \text{Liters} \]

We will then need two formulas for these problems one for \( V_1 \) and one for \( V_2 \)

Since we are simply taking a ratio of a final fixed volume \( V_3 \) that will be given in the problem. We can set the formula up to recapture what we did in the dilution rectangle......

\[ V_1 = \frac{(C_3-C_2)}{(C_1-C_2)} \times V_3 \]
\[ V_1 = \frac{(5\%-3\%)}{(8\%-3\%)} \times 90 \text{Liters} \]
\[ V_1 = \frac{2}{5} \times 90 \text{Liters} \]
\[ V_1 = 36 \text{Liters} \]

\[ V_2 = \frac{(C_1-C_3)}{(C_1-C_2)} \times V_3 \]
\[ V_2 = \frac{(8\%-5\%)}{(8\%-3\%)} \times 90 \text{Liters} \]
\[ V_2 = \frac{3}{5} \times 90 \text{Liters} \]
\[ V_2 = 54 \text{Liters} \]

Using our last example

\[ \text{Checking our Results} = 54 + 36 = 90 \]
\[ \text{Must be correct!!!} \]

\( C_1 \), \( C_2 \), and \( C_3 \) work well with these problems as long as you remember that you are solving for two unknown volumes from a final always given \( V_3 \).
Consider the following:

How many liters of WATER and a 9% solution should be used to make 90 liters of a 4% solution?

RULE 2 OF THE DILUTION RECTANGLE When blending Any concentration with water—consider water to be the lowest concentration set it at “0”.

So our new letter assignments for both the rectangle and the Two volume formulas are:

- **C₁** = Highest Concentration Also A for the rectangle.
- **C₂** = Lowest Concentration 0 for water Also B for the rectangle.
- **C₃** = Desired or final Concentration C for the rectangle.
- **V₁** = Volume or flow rate for the highest concentration
- **V₂** = Volume or flow rate for the lowest concentration
- **V₃** = Volume or flow rate for the desired concentration
How many liters of WATER and a 9% solution should be used to make 90 liters of a 4% solution?

\[ C-B = 39.96 \text{Liters Of 9% Solution} \]
\[ = 4 \]
\[ \frac{4}{9} \times 90 \text{Liters} \]
\[ = 0.444 \times 90 \text{Liters} \]
\[ = 39.96 \text{Liters} \]
\[ = 50.04 \text{Liters of Water} \]
\[ \Phi \frac{5}{9} \]
\[ \frac{5}{9} \times 90 \text{Liters} \]
\[ = 0.556 \times 90 \text{Liters} \]
\[ = 50.04 \text{Liters} \]

\[ C_1 = \text{Highest Concentration} \]
\[ C_2 = \text{Lowest Concentration} \]
\[ C_3 = \text{Desired or final Concentration} \]
\[ V_1 = \text{Volume or flow rate for the highest concentration} \]
\[ V_2 = \text{Volume or flow rate for the lowest concentration} \]
\[ V_3 = \text{Volume or flow rate for the desired concentration} \]

We will then need two formulas for these problems, one for \( V_1 \) and one for \( V_2 \).

Since we are simply taking a ratio of a final fixed volume \( V_3 \) that will be given in the problem. We can set the formula up to recapture what we did in the dilution rectangle…..

\[ V_1 = \frac{(C_3-C_2)}{(C_1-C_2)} \times V_3 \]
\[ V_1 = \frac{(4\%-0\%)}{(9\%-0\%)} \times 90 \text{Liters} \]
\[ V_1 = \frac{4}{9} \times 90 \text{Liters} \]
\[ V_1 = 40 \text{Liters} \]

\[ V_2 = \frac{(C_1-C_2)}{(C_1-C_2)} \times V_3 \]
\[ V_2 = \frac{(9\%-4\%)}{(9\%-0\%)} \times 90 \text{Liters} \]
\[ V_2 = \frac{5}{9} \times 90 \text{Liters} \]
\[ V_2 = 50 \text{Liters} \]

Remember when using water make it 0 and assign it to \( C_2 \) for the lowest concentration.

Chapter 1-19
Consider the following:

A well is pumping water into a blending system containing 60 mg/L of nitrate and is blended with purchase water containing 10 mg/L of nitrate. The total flow for both sources combined is 3,800 gallons per minute (GPM). You need to blend these waters together to achieve 20 mg/L of nitrate in your distribution system. What will the flow from the well in GPM that you will need to blend with the purchase water?

\[ V_1 = ? \]

\[ V_2 = ? \]

How many GPM needed from the well (at 60 mg/L) mixed with Purchase water (at 10 mg/L) to achieve 20 mg/L of nitrate in 3,800 GPM Flow?

\[
\begin{align*}
    A & \quad \text{High Concentration} \\
    \text{60 mg/L} & \\
    \text{C-B} & \quad 20 \text{-} 10 \\
    \quad & = 760 \text{GPM of 60 mg/L Flow from Well} \\
    \text{C} & \quad \text{Desired Concentration} \\
    \text{20 mg/L} & \\
    \text{SO} & \\
    \quad & = 10 \\
    B & \quad \text{Low Concentration} \\
    \text{10 mg/L} & \\
    \text{A-C} & \quad 60 \text{-} 20 \\
    \quad & = 3,040 \text{GPM of purchase water} \\
    \quad & \div 40 \\
    \quad & = 0.8 \times 3,800 \text{GPM} \\
\end{align*}
\]
Consider the following:

The finished water from your water treatment plant contains 65 mg/L of nitrates and exceeds the MCL of 45 mg/L of nitrates. You can purchase water from another water treatment plant which contains only 10 mg/L of nitrates for blending. After blending the finished flow is 8,000 GPM and the nitrate level is now 30 mg/L. What is the required GPM of the purchase water (from the other plant) that got you to this new blended concentration?

V1 = ? Flow in GPM out of your WTP@65ppm of nitrates
V2 = ? Flow in GPM out of the purchase water Plant @ 10ppm nitrates.

Be careful here…. The MCL is nice information but has nothing to do with solving the problem.
How many GPM needed from the WTP1 (@65 mg/L) mixed with WTP2 (@10 mg/L) to achieve 30 mg/L of nitrate in 8,000 GPM flow?

\[
\begin{align*}
A & \quad \text{High Concentration} \quad 65 \text{mg/L} \\
B & \quad \text{Low Concentration} \quad 10 \text{mg/L} \\
C & \quad \text{Desired Concentration} \quad 30 \text{mg/L} \\
\text{C-B} & \quad 30-10 \\
\text{C} & \quad 2909 \text{GPM of 65 mg/L Flow WTP1} \\
& = 20 \\
& = \frac{20 \times 8000}{55} \\
& = 0.3636 \times 8000 \text{GPM} \\
& = 2909 \text{GPM} \\
\text{A-B} & \quad 65-30 \\
\text{A-C} & \quad 5091 \text{GPM of purchase WTP2} \\
& = \frac{5091}{35} \times 8000 \text{GPM} \\
& = 0.6364 \times 8000 \text{GPM} \\
& = 5091 \text{GPM}
\end{align*}
\]

\[\begin{align*}
C_1 &= \text{Highest Concentration} \quad 65 \text{mg/L} \\
C_2 &= \text{Lowest Concentration} \quad 10 \text{mg/L} \\
C_3 &= \text{Desired} \text{ Concentration} \quad 30 \text{mg/L} \\
V_1 &= \text{Volume as a flow rate for the highest concentration in GPM} = \text{WTP1 GPM} \\
V_2 &= \text{Volume as a flow rate for the lowest concentration in GPM} = \text{purchase GPM} \\
V_3 &= \text{Volume as a flow rate for the desired concentration in GPM} = 8000 \text{GPM}
\end{align*}\]

Again we are solving for two flow volumes = \(V_1\) and one for \(V_2\)

Again we are dealing with one final flow volume which is almost always given in these types of problems \(V_3 = 8000 \text{GPM}\)

\[
\begin{align*}
V_1 &= \frac{(C_3 - C_2)}{(C_1 - C_2)} \times V_3 \\
V_1 &= \frac{(30-10 \text{mg/L})}{(65-10 \text{mg/L})} \times 8000 \text{GPM} \\
&= \frac{20}{55} \\
&= 0.3636 \times 8000 \text{GPM} \\
&= 2909 \text{GPM}
\end{align*}
\]

\[
\begin{align*}
V_2 &= \frac{(C_1 - C_3)}{(C_1 - C_2)} \times V_3 \\
V_2 &= \frac{(65-30 \text{mg/L})}{(65-10 \text{mg/L})} \times 8000 \text{GPM} \\
&= \frac{35}{55} \\
&= 0.6364 \times 8000 \text{GPM} \\
&= 5091 \text{GPM}
\end{align*}
\]

Go the Dilution Rectangle section provided for some additional problems you might see on the test.