Advanced Math

Using Multiple Formulas

1. **How many pounds of pure chlorine are needed to apply a 12.5 mg/l dosage to a tank that is 10 ft tall, 30 ft wide, and 25 ft long?**

Step 1 - Starting Material

Dosage = 12.5 mg/l *(information in question)*
Height = 10 ft *(information in question)*
Width = 30 ft *(information in question)*
Length = 25 ft *(information in question)*
Lbs. pure chlorine = ? *(what you are looking for)*

Step 2A – Write down the formula.

(MG) (mg/l) (8.34) = lbs. *(this formula will give the final answer)*

Step 3A – Fill numbers into the formula.

(MG) (12.5 mg/l) (8.34) = lbs.
(There is another piece of information missing, so a second formula will need to be used)

Step 2 – Write down the formula.

Volume = Length x Width x Height
(MG stands for Million Gallons, a volume measurement)

Step 3 – Fill numbers into the formula.

Volume = 25 ft x 30 ft x 10 ft

Step 4 – Calculate

25 x 30 x 10 = 7,500 cu. ft. (*Volume needs to be converted to gallons)*
7,500 cu. ft. x 7.48 = 56,100 gallons
➔ **MG = 0.0561** *(Use this value to complete the first formula)*

Step 3B – Fill numbers into the formula.

(0.0561) (12.5 mg/l) (8.34) = lbs.

Step 4 – Calculate

0.0561 x 12.5 x 8.34 = 5.8 mg/l Dosage

2. **Calculate the dosage given to a 750,000-gallon system after adding 20 pounds of 85% calcium hypochlorite?**

Step 1 - Starting Material

750,000 gal *(information in question)*

➔MG = 0.75 *(move decimal to the left 6 places)*

Compound Chlorine = 20 lbs. *(information in question)*

85% chlorine *(information in question)*

➔Chlorine strength = 0.85 *(move decimal to the left 2 places)*

Dosage = ? *(what you are looking for)*

Step 2A – Write down the formula.

Dosage in mg/l = Lbs. chemical *(Lbs. chemical is PURE chlorine)*

MGD x 8.34, *(This formula will give the final answer)*

Step 3A – Fill numbers into the formula.

Dosage in mg/l = Lbs. chemical *(There is another piece of information missing)*

0.75 x 8.34

Step 2 – Write down the formula.

Lbs. of compound = Lbs. pure chlorine divided by % chlorine

Step 3 – Fill numbers into the formula.

20 lbs. = Lbs. pure chlorine ÷ 0.85 *Unknown value must be by itself.*

Lbs. pure chlorine = 20 lbs. x 0.85

Step 4 – Calculate

20 x 0.85 = 17 lbs. pure chlorine *(Use this value to complete the first formula)*

Step 3B – Fill numbers into the formula.

Dosage in mg/l = 17 lbs.

0.75 x 8.34

Step 4 – Calculate

Dosage in mg/l = 17 lbs.

6.255 *(You must do what is on bottom first.)*

17 ÷ 6.255 = 2.7 mg/l dosage

3. **Calculate the demand of a 4 ft diameter by 16 ft tall round tank that was disinfected with 5 pounds of 8% bleach and has a sustained residual of 2.6 mg/l?**

Step 1 - Starting Material

Diameter = 4 ft *(information in question)*

Radius = 2 ft *(radius is half the diameter)*

Height = 16 ft *(information in question)*

Compound Chlorine = 5 lbs. *(information in question)*

8% chlorine *(information in question)*

➔Chlorine strength = 0.08 *(move decimal to the left 2 places)*

Residual = 2.6 mg/l *(information in question)*

Demand = ? *(what you are looking for)*

Step 2A – Write down the formula.

Dosage = Demand + Residual *(This formula will give the final answer)*

Step 3A – Fill numbers into the formula.

Dosage = Demand + 2.6 mg/l *(There is another piece of information missing)*

Step 2 – Write down the formula.

Dosage in mg/l = Lbs. chemical *(Lbs. chemical is PURE chlorine)*

MGD x 8.34,

Step 3A – Fill numbers into the formula.

Dosage in mg/l = Lbs. chemical

MGD x 8.34 *(There are two pieces of information missing)*

Step 2A – Write down the formula.

Lbs. compound = Lbs. pure chlorine divided by % chlorine

Step 3A – Fill numbers into the formula.

5 lbs. = Lbs. pure chlorine ÷ 0.08 *Unknown value must be by itself.*

Lbs. pure chlorine = 5 lbs. x 0.08

Step 4A – Calculate

5 x 0.08 = 0.4 lbs. pure chlorine *(Use this value to complete the second formula)*

Step 2B – Write down the formula.

Volume = πr^2 x height

Step 3B – Fill numbers into the formula.

Volume = 3.14 x 2 ft x 2 ft x 16 ft

Step 4B – Calculate

3.14 x 2 x 2 x 16 = 200.96 cu. ft. *(Volume needs to be converted to gallons)*

200.96 cu. ft. x 7.48 = 1,503 gallons

➔ **MG = 0.0015** *(Use this value to complete the second formula)*

Step 3 – Fill numbers into the formula.

Dosage in mg/l = ___0.4 lbs.___

0.0015 x 8.34

Step 4 – Calculate

Dosage in mg/l = ___0.4 lbs.__

0.01251 *(You must do what is on bottom first.)*

0.4 ÷ 0.01251 = 32 mg/l dosage *(Use this value to complete the first formula)*

Step 3B – Fill numbers into the formula.

32 mg/l = Demand + 2.6 mg/l *Unknown value must be by itself*

Demand = 32 mg/l – 2.6 mg/l

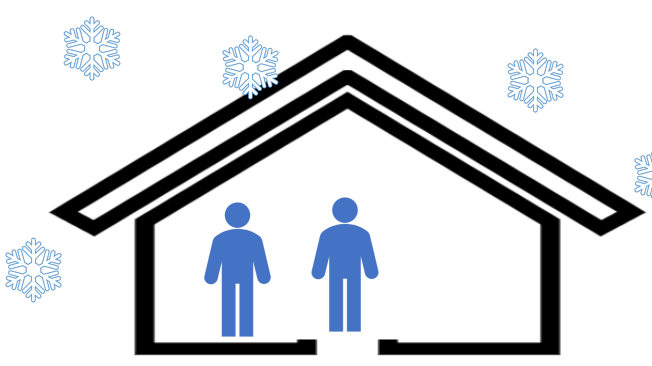
Step 4 – Calculate

32 – 2.6 = 29.4 mg/l demand

Advanced Math Strategies

Equations to MEMORIZE!

- **EBCT = V ÷ F**
  - V = volume of media
  - F = Flow of water
  - Make sure units match
- **Feed = Permeate + Concentrate**
  - Feed = Water entering R.O.
  - Permeate = Portion of feed water moving through R.O. as Product
  - Concentrate = Portion of feed water Rejected as Waste
- **% Recovery = Permeate ÷ Feed x 100**
  - Percent of water entering an R.O. that becomes Product
- **1˚f change = 1.5% change in production rate**
  - First, find how much the temp. changed x 1.5 = % production change
  - Second, change % to a decimal and multiply by starting prod. rate
  - Third, add or subtract this number from the starting prod. rate
    - Colder = Subtract, Warmer = Add
- **1 psi = 100 ppm TDS Difference**
  - 1 psi of osmotic backpressure towards the feed side for every 100 ppm TDS removed during R.O.



Permanent = Non-Carbonate

Temporary = Carbonate

Empty Bed Contact Time

1. **Determine the amount of carbon media in cu. ft. needed to remove Hydrogen Sulfide if the flow rate is 2.5 GPM. According to the carbon manufacturer, an EBCT of 4.5 minutes is adequate for Hydrogen Sulfide removal.**

Step 1 - Starting Material

Flow = 2.5 GPM *(information in question)*

EBCT = 4.5 min *(information in question)*

Volume = ? cu. ft. *(answer unit)*

Step 2 – Write down the formula.

EBCT = Volume ÷ Flow

Not found on the "Conversion Table". Memorize.

Step 3 – Fill numbers into the formula.

4.5 min = Volume ÷ 2.5 GPM *Unknown value must be by itself*

Volume = 4.5 min x 2.5 GPM

Step 4 – Calculate and convert.

4.5 x 2.5 = 11.25 gal

Make sure that your answer is in the unit that the question asked for.

11.25 ÷ 7.48 = 1.5 cu. ft.

2. **An activated carbon canister is 6 inches in diameter and 18 inches high. The carbon occupies 70% of the canister volume. If the flow rate is 0.11 gallons per minute, what is the EBCT in minutes?**

Step 1 - Starting Material

Diameter = 6 in = 0.5 ft *(information in question, ALWAYS convert to feet)*

Radius = 0.25 ft *(radius is half the diameter)*

Height = 18 in = 1.5 ft *(information in question, ALWAYS convert to feet)*

Carbon volume = 70% of Canister volume

Flow = 0.11 GPM *(information in question)*

EBCT = ? min *(What you are looking for)*

Step 2 – Write down the formula.

EBCT = Volume ÷ Flow *(Memorize formula) (Volume refers to media* (carbon))

Step 3A – Fill numbers into the formula.

EBCT = Volume ÷ 0.11 GPM *(There is another piece of information missing)*

Step 2 – Write down the formula.

Volume = πr^2 x Height

Step 3 – Fill numbers into the formula.

Volume = 3.14 x 0.25 ft x 0.25 ft x 1.5 ft

Step 4 – Calculate

3.14 x 0.25 x 0.25 x 1.5 = 0.29 cu. ft. *(Convert to gallons to match flow units)*

0.29 cu. ft. x 7.48 = 2.2 gallons *(This is the total canister volume; you need media volume)*

Step 2 – Write down the formula.

Carbon volume = 70% of canister volume

Step 3A – Fill numbers into the formula.

Carbon volume = 0.70 x 2.2 gal *("of" means to multiply)(change "%"to a decimal)*

Step 4A – Calculate

0.70 x 2.2 = 1.5 gal Carbon *(Use this value to complete the first equation)*

Step 3B – Fill numbers into the formula.

EBCT = 1.5 gal ÷ 0.11 GPM

Step 4 – Calculate

1.5 ÷ 0.11 = <u>14 min EBCT</u>

Water Analysis

1. **From the following water analysis, determine the type and amount of hardness:**

   Total alkalinity = 300 mg/l ***(Alkalinity is jackets)***

   Hardness = 200 mg/l ***(Hardness is People)***

   Use the picture story

   There are 200 people and 300 jackets. Therefore:

   All 200 people can put on a jacket and go outside.

   There are 0 people left inside the house.

   There are 100 extra jackets laying on the floor.

   Temporary Hardness: _200 mg/l__ ***(Temporary hardness = People outside)***

   Permanent Hardness: ___0 mg/l__ ***(Permanent hardness = People inside)***

2. **From the following water analysis, determine the type and amount of hardness:**

   Total alkalinity = 150 mg/l ***(Alkalinity is jackets)***

   Hardness = 350 mg/l ***(Hardness is People)***

   Use the picture story

   There are 350 people and 150 jackets. Therefore:

   150 people can put on a jacket and go outside.

   There are 200 people left inside the house.

   There are 0 extra jackets laying on the floor.

   Temporary Hardness: _150 mg/l__ ***(Temporary hardness = People outside)***

   Permanent Hardness: _200 mg/l__ ***(Permanent hardness = People inside)***

R.O.

1. **Calculate the feed to an RO that is producing 5 gpm permeate and 15 gpm concentrate.**

Step 1 - Starting Material

Permeate = 5 gpm *(information in question)*

Concentrate = 15 gpm *(information in question)*

Feed = ? *(what you are looking for)*

Step 2 – Write down the formula.

Feed = Permeate + Concentrate *(Not found on the "Conversion Table". Memorize)*

Step 3 – Fill numbers into the formula.

Feed = 5 gpm + 15 gpm

Step 4 – Calculate

5 + 15 = <u>20 gpm feed</u>

2. **Calculate the concentrate to an RO that is producing 10 gpm permeate and with a 40 gpm feed.**

Step 1 - Starting Material

Permeate = 10 gpm *(information in question)*

Feed = 40 gpm *(information in question)*

Concentrate = ? *(what you are looking for)*

Step 2 – Write down the formula.

Feed = Permeate + Concentrate *(Not found on the "Conversion Table". Memorize)*

Step 3 – Fill numbers into the formula.

40 gpm = 10 gpm + Concentrate *(Unknown value must be by itself.)*

Concentrate = 40 gpm – 10 gpm

Step 4 – Calculate

40 - 10 = <u>30 gpm Concentrate</u>

3. **Calculate the recovery of an RO that has a 80 gpd feed and produces 20 gpd.**

Step 1 - Starting Material

Feed = 80 gpd *(information in question)*

Permeate = 20 gpd *(information in question, Product = Permeate)*

Recovery = ? *(what you are looking for)*

Step 2 – Write down the formula.

% Recovery = Permeate /Feed x 100 *(Not found on the "Conversion Table". Memorize)*

Step 3 – Fill numbers into the formula.

% Recovery = 20 gpd / 80 gpd x 100

Step 4 – Calculate

20 / 80 x 100 = 0.25 x 100 = <u>25%</u>

4. **When 6 gallons of permeate and 24 gallons of concentrate are produced by an RO unit, what is the recovery?**

Step 1 - Starting Material

Permeate = 6 gal *(information in question)*

Concentrate = 24 gal *(information in question)*

Recovery = ? *(what you are looking for)*

Step 2 – Write down the formula.

% Recovery = Permeate /Feed x 100 *(Not found on the "Conversion Table". Memorize)*

Step 3A – Fill numbers into the formula.

% Recovery = 6 gal / Feed x 100 *(There is another piece of information missing)*

Step 2 – Write down the formula.

Feed = Permeate + Concentrate

Step 3 – Fill numbers into the formula.

Feed = 6 gal + 24 gal

Step 4 – Calculate

6 + 24 = 30 gal Feed *(Use this value to complete the first formula)*

Step 3B – Fill numbers into the formula.

% Recovery = 6 gal / 30 gal x 100

Step 4 – Calculate

6 / 30 x 100 = 0.2 x 100 = <u>20%</u>

5. **Calculate the osmotic back pressure on an RO that has 1600 TDS feed and 100 TDS permeate.**

Step 1 - Starting Material

Feed TDS = 1600 ***(information in question)***

Permeate TDS = 100 ***(information in question)***

Osmotic back pressure = ? ***(what you are looking for)***

Osmotic pressure: 1 psi = 100 TDS difference ***(Memorize)***

Step 2 – Find the difference across the Membrane

1600 TDS ➔ in *[Membrane]* 100 TDS ➔ out

1600 – 100 = 1500 TDS difference

Step 3 – Calculate pressure from TDS difference

Osmotic pressure = TDS difference ÷ 100

1500 ÷ 100 = <u>15 psi Osmotic Back Pressure</u>

6. **An RO unit is making 20 gph at 77*f. If the temperature drops to 65*f what will the production rate be?**

Step 1 - Starting Material

Starting Production Rate = 20 gph ***(information in question)***

Starting Temperature = 77*f ***(information in question)***

Ending Temperature = 65*f ***(information in question)***

Ending Production Rate= ? ***(what you are looking for)***

1*f temperature change = 1.5% change in production ***(Memorize)***

Step 2 – Find Temperature change

Temperature change = Starting Temperature – Ending Temperature

77*f – 65*f = 12*f temperature change

Step 3 – Find % change in production

% change in production = Temperature change x 1.5%

12*f x 1.5% = 18% Change in production

Step 4 – Find exact change in production

Change in production = % change x Starting Production Rate

0.18 x 20 gph = 3.6 gph Change in production ***(Change % to decimal)***

Step 5 – Find Ending Production Rate

Ending Production Rate = Starting Production (+or-) Change in Production

(If it got warmer you add, if it got colder you subtract)

30 gph – 3.6 gph = <u>16.4 gph Ending Production Rate</u>

Softener Math!

Using the Diagram, answer the following Questions:

1. **How many cubic feet of resin does the unit contain?**

   Diameter = 36 in = 3 ft Radius = 1.5 ft Height = D = 4 ft

   Volume = π r² x Height

   Volume = 3.14 x 1.5 ft x 1.5 ft x 4 ft = 28.26 cu. ft

2. **How many gallons of water can the freeboard hold?**

   Diameter = 36 in = 3 ft Radius = 1.5 ft Height =1/2 D = 2 ft

   Volume = π r² x Height

   ***Volume = 3.14 x 1.5 ft x 1.5 ft x 2 ft* = 14.13 cu. ft. = 105.7 gal**