Ionico Technical Services

Advanced Math

By Stephanie Layfield

Remember

- There are always 4 steps to follow with a word problem:
  1. Write down given numbers with units.
  2. Write down the correct formula.
  3. Fill numbers into formula.
  4. Calculate and convert to correct units.
- During step number 2, make sure that you have only unknown (?) value to fill in.

Using Multiple Formulas

- Sometimes more than one formula will be needed to get to the right answer.
- Be very clear when you list your numbers in step 1.
- It may be beneficial to work backwards.
  - Start with a formula that will give you the right answers and use other formulas to help fill in the needed information.

1. Using Multiple Formulas

- 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
  - Height =10 ft Dosage = 12.5 mg/l
  - Width = 30 ft Lbs. = ?
  - Length = 25 ft
- Step 2
  - (MG) (mg/l) (8.34) = lbs.
  - V = Length x Width x Height
- Step 3
  - V = 25 ft. x 30 ft. x 10 ft. Lbs = (MG) (12.5) (8.34)
- Step 4
  - V = 7,500 cu. ft. x 7.48 = 56,100 gallons = 0.0561 MG
  - Lbs. = 0.0561 x 12.5 x 8.34 = 5.8 lbs

2. Using Multiple Formulas – Your Turn!

- Calculate the dosage given to a 750,000-gallon system after adding 20 pounds of 85% calcium hypochlorite?
- Step 1
  - 750,000 gal = 0.75 MG Dosage = ?
  - 20 lbs compound 85% Cl_2 = 0.85 Cl_2
- Step 2
  - Dosage = Lbs. / (MGD x 8.34)
  - Lbs. compound = Lbs. pure / % Cl_2
- Step 3
  - Dosage = Lbs / (0.75 x 8.34) 20 = Lbs / 0.85
- Step 4
  - 20 = Lbs / 0.85 Lbs = 20 x 0.85 = 17 Lbs
  - Dosage = 17 / (0.75 x 8.34) = 17 / (6.255) = <u>2.7 mg/l</u>

3. Using Multiple Formulas – Challenge Question!

- 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
  - Demand = ? Diameter = 4 ft Radius =2 ft Height = 16 ft
  - Residual = 2.6 mg/l 5 lbs. = compound 8% = 0.08 Cl_2
- Step 2
  - Dosage = Demand + Residual $V = \pi r^2 \times$ Height
  - Dosage = Lbs. / (MGD x 8.34) Lbs. Compound = Lbs. pure / % chlorine
- Step 3
  - Dosage = ? + 2.6 mg/l $V = 3.14 \times 2 \times 2 \times 16$
  - Dosage = Lbs. / (MGD x 8.34) 5 = Lbs. pure / 0.08
- Step 4
  - V= 200.96 c.f.= 1,503 g.= 0.0015 MG 5= Lbs. pure/0.08 ➔ 5 x 0.08= 0.4 lbs.
  - Dosage = 0.4/ (0.0015 x 8.34) = 0.4/0.01251 = 32 mg/l
  - 32 mg/l = Demand + 2.6 mg/l Demand = 32 mg/l - 2.6 mg/l = <u>29.4 mg/l</u>

Empty Bed Contact Time

- EBCT is the theoretical detention time calculated by using the volume occupied by the media.
- EBCT = V / F
  - V = Volume of Media
  - F = Flow of Water

1. Empty Bed Contact Time

- 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
  - Flow = 2.5 GPM
  - EBCT = 4.5 min.
  - Volume = ?
- Step 2
  - EBCT = V / F
- Step 3
  - 4.5 min. = ? / 2.5 GPM
- Step 4
  - ? = 4.5 min. x 2.5 GPM = 11.25 gal. → ÷ 7.48 = <u>1.5 cu. ft. media</u>

2. Empty Bed Contact Time – Your Turn!

- 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
  - Diameter = 6 in = 0.5 ft Radius = 0.25 ft Height = 18in = 1.5 ft
  - V media = 70% x V total Flow = 0.11 GPM EBCT = ?
- Step 2
  - V total = π x r^2 x height EBCT = V media / Flow
- Step 3
  - EBCT = V media / 0.11 GPM
  - V total = 3.14 x 0.25 x 0.25 x 1.5 V media = 0.70 x V total
- Step 4
  - V = 0.29 cu. ft. x 7.48 = 2.2 gal. V media = 0.70 x 2.2 gal = 1.5 gal
  - **EBCT = 1.5 gal. / 0.11 GPM = <u>14 minutes</u>**

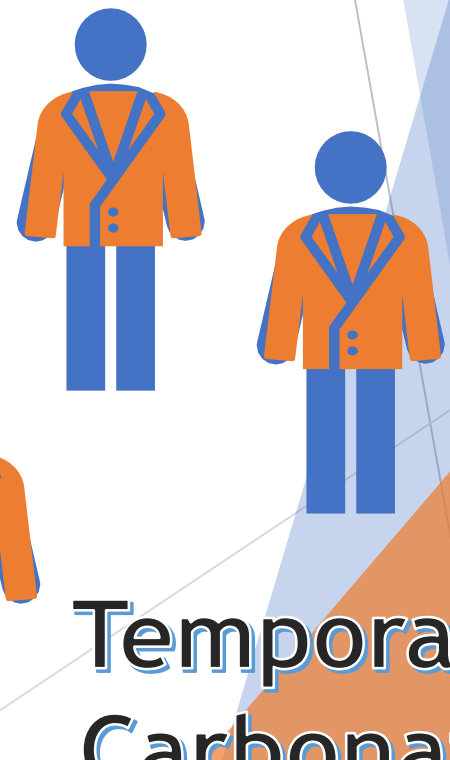
Water Analysis

- In a water analysis that gives you total alkalinity and total hardness, you can calculate how much is temporary hardness and how much is permanent hardness
- Temporary = Carbonate Hardness
  - Hardness covered by alkalinity
- Permanent = Non-Carbonate Hardness
  - Total hardness – Temporary hardness

Water Analysis

Hardness =

Alkalinity =



Temporary
Carbonate

3

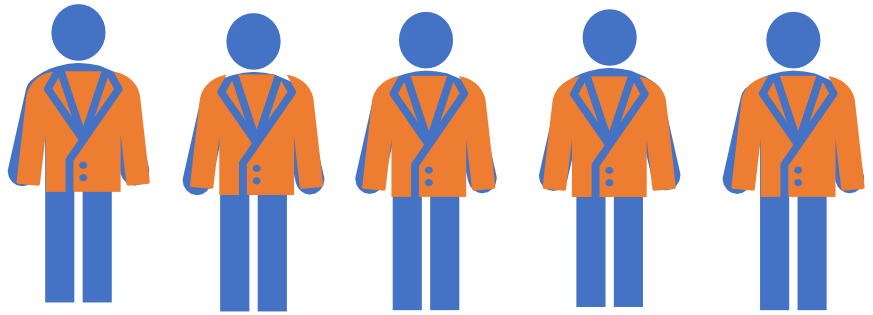
Water Analysis

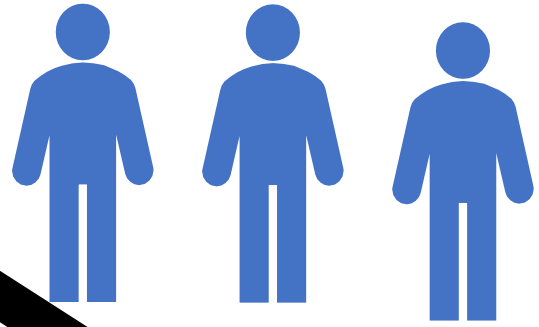
Total Hardness = 8 mg/l

Total Alkalinity = 5 mg/l

Hardness =

Alkalinity =





Temporary
Carbonate
5

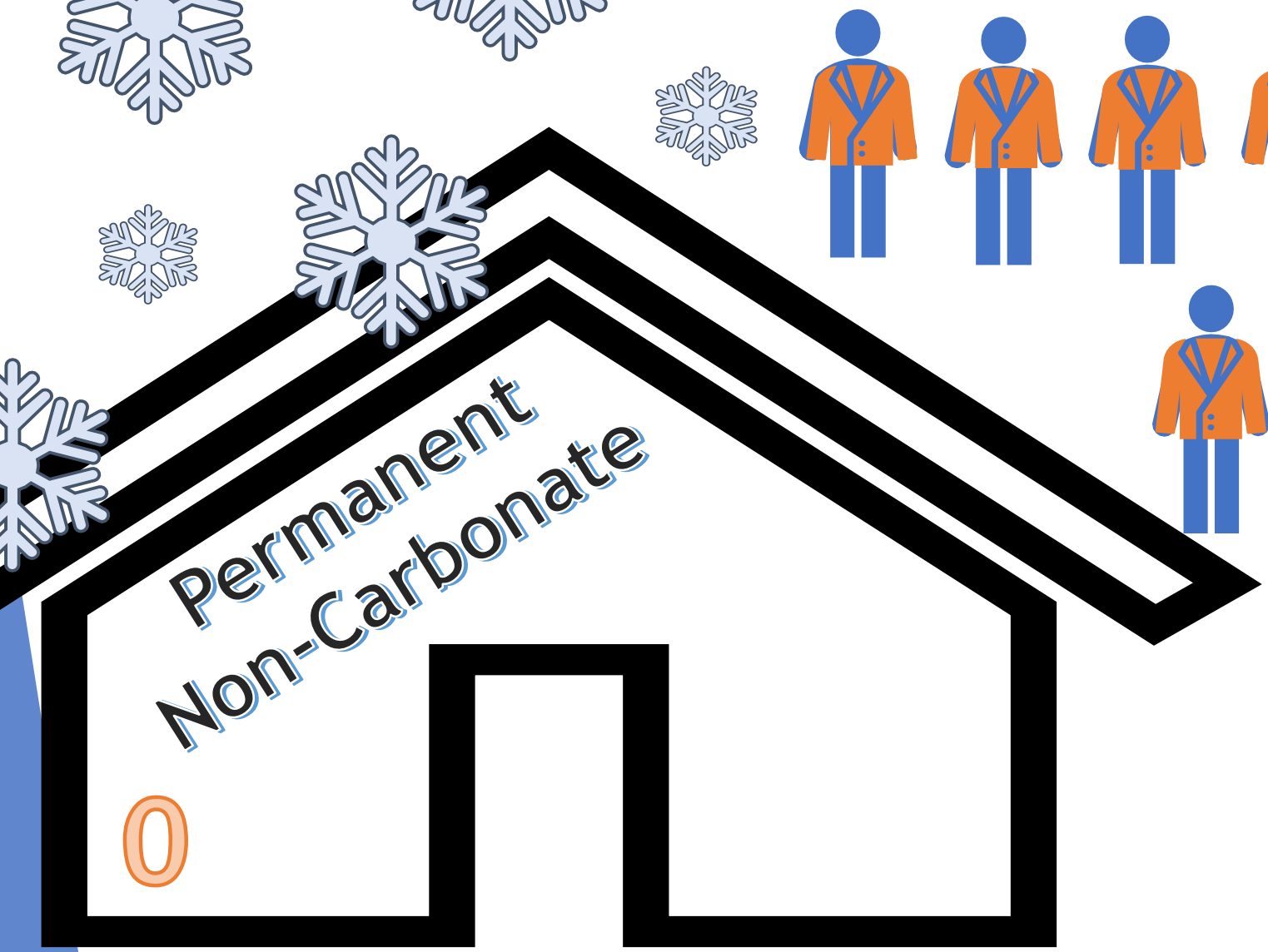
Water Analysis

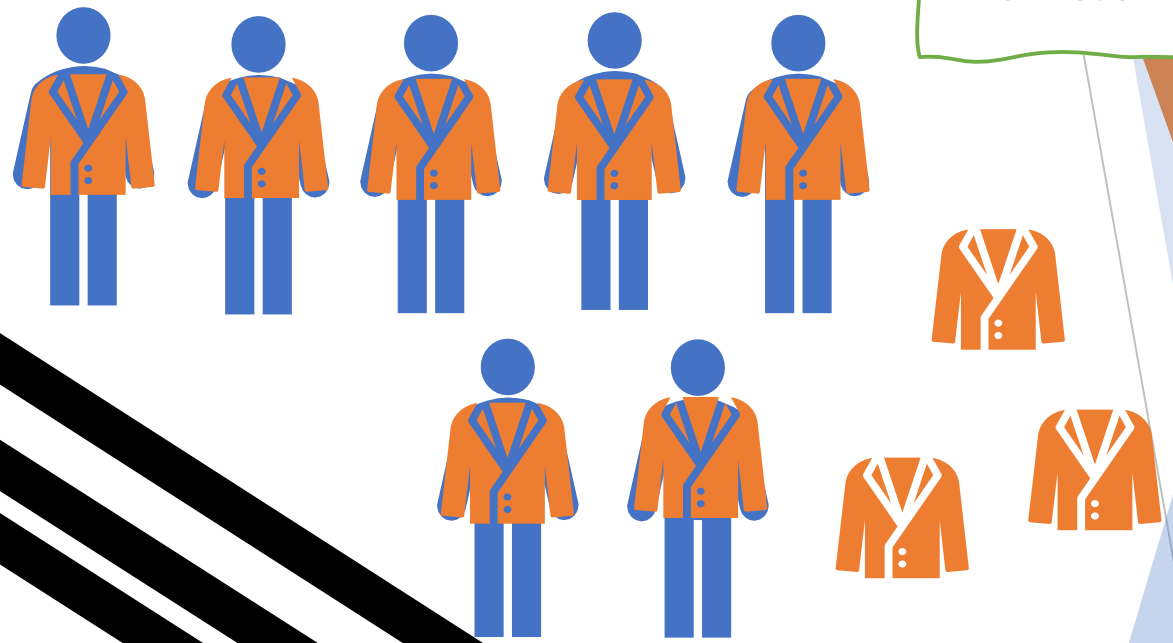
Total Hardness = 7 mg/l

Total Alkalinity = 10 mg/l

Hardness =

Alkalinity =





Temporary
Carbonate
7

1. Water Analysis

- From the following water analysis, determine the type and amount of hardness.
  - Total alkalinity = 300 mg/l
  - Total Hardness = 200 mg/l

Temporary (Carbonate) Hardness = 200 mg/l

Permanent (Non-Carbonate) Hardness = 0 mg/l

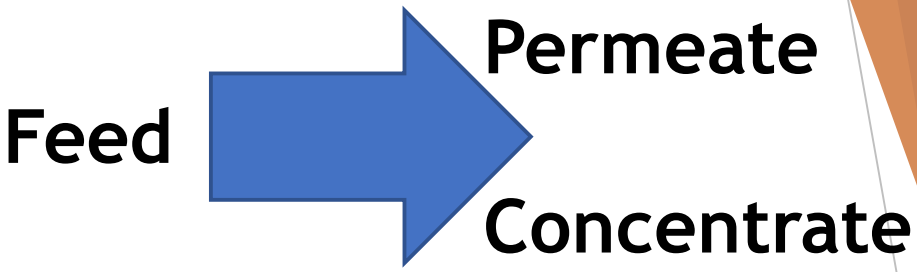
2. Water Analysis – Your Turn!

- From the following water analysis, determine the type and amount of hardness.
  - Total alkalinity = 150 mg/l
  - Total Hardness = 300 mg/l

Temporary (Carbonate) Hardness = 150 mg/l

Permanent (Non-Carbonate) Hardness = 200 mg/l

RO Math



- Feed = Permeate + Concentrate
- Recovery = % product through an RO unit
  - % Recovery = Permeate / Feed
- RO's produce more at higher temperatures
  - 1.5% increase per *F temperature change
- Osmosis Pressure
  - 1 psi = 100 ppm TDS Difference

1. RO Math

- Calculate the feed to an RO that is producing 5 gpm permeate and 15 gpm concentrate.
- Step 1
  - Permeate = 5 gpm
  - Concentrate = 15 gpm
  - Feed = ?
- Step 2
  - Feed = Permeate + Concentrate
- Step 3
  - Feed = 5 gpm + 15 gpm
- Step 4
  - Feed = <u>20 gpm</u>

2. RO Math – Your Turn!

- **Calculate the concentrate to an RO that is producing 10 gpm permeate and with a 40 gpm feed.**
- **Step 1**
  - **Permeate = 10 gpm**
  - **Feed = 40 gpm**
  - **Concentrate = ?**
- **Step 2**
  - **Feed = Permeate + Concentrate**
- **Step 3**
  - **40 gpm = 10 gpm + ? ➔ ? = 40 gpm - 10 gpm**
- **Step 4**
  - **Concentrate = <u>30 gpm</u>**

3. RO Math

- Calculate the recovery of an RO that has a 80 gpd feed and produces 20 gpd.
- Step 1
  - Feed = 80 gpd
  - Product = 20 gpd
  - Recovery = ?
- Step 2
  - % Recovery = permeate / Feed x 100
- Step 3
  - ? = 20 / 80 x 100
- Step 4
  - % Recovery = 25%

4. RO Math – Your Turn!

- When 6 gallons of permeate and 24 gallons of concentrate are produced buy an RO unit, what is the recovery?
- Step 1
  - Permeate = 6 gallons
  - Concentrate = 24 gallons
  - Recovery = ?
- Step 2
  - % Recovery = permeate / Feed x 100
  - Feed = Permeate + Concentrate
- Step 3
  - ? = 6 / Feed x 100 Feed = 6 + 24
- Step 4
  - Feed = 30 % Recovery = 6/30 x 100 = <u>20%</u>

5. RO Math – Your Turn!

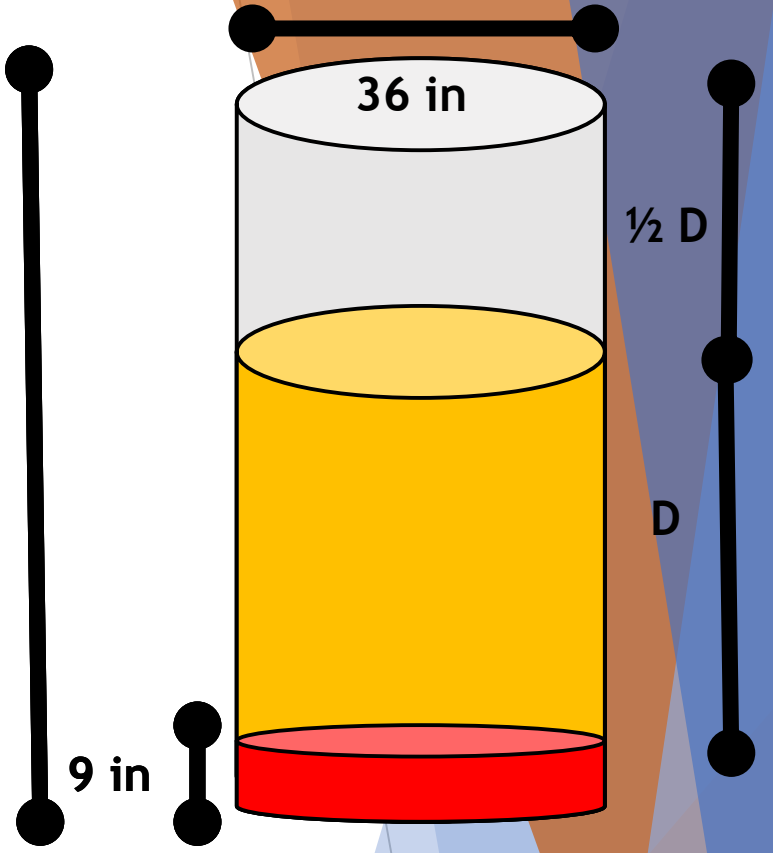
- Calculate the osmotic back pressure on an RO that has 1600 TDS feed and 100 TDS permeate.
- Step 1
  - Feed = 1600 ppm
  - Permeate = 100 ppm
  - Osmotic pressure = ? psi
- Step 2
  - TDS difference = Feed TDS - Permeate TDS
  - Pressure = TDS diff. / 100
- Step 3
  - TDS diff. = 1600 ppm - 100 ppm Pressure = TDS diff. / 100
- Step 4
  - TDS diff. = 1500 Pressure = 1500 / 100 = **15 psi**

6. RO Math – Your Turn!

- **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
  - Production = 20 gph
  - Start temp = 77*f End temp = 65 *f
  - New production = ? gph
- Step 2
  - Change in production = 1.5% x change in temp
  - Change in temp = Start temp - End Temp
- Step 3
  - Change in temp = 77 - 65 % change= 1.5% x Change in temp
  - Change in production = % change x Start Production
  - New production = Production - change in production (colder)
- Step 4
  - Change in temp = 12*f Change in prod. = 1.5% x 12 = 18% 0.18 x 20 = 3.6 gph
  - 20 gph - 3.6 gph = **16.4 gph**

Last Page of the Exam!

- Using the Diagram, answer the following questions:
- How many cubic feet of resin does the unit contain?
- How many gallons of water can the freeboard hold?



Last Page of the Exam!

- Using the Diagram, answer the following questions:
- How many cubic feet of resin does the unit contain?
- How many gallons of water can the freeboard hold?
- Step 1
  - Diameter = 36 in. = 3 ft. Radius = 1.5 ft.
  - Height $_{Total}$ = 81 in. Height $_{Support}$ = 9 in.
  - Height $_{Resin}$ = D Height $_{F.B.}$ = ½ D
- Step 2
  - V = π x r^2 x Height Height $_{F.B.}$ = ½ Height $_{Resin}$
- Step 3
  - Height $_{Tank}$= 81 in - 9 in Height $_{Total}$ = D + ½ D
  - V $_{resin}$ = 3.14 x 1.5 x 1.5 x Height $_{Resin}$ V $_{F.B.}$ = 3.14 x 1.5 x 1.5 x F.B. Height $_{F.B.}$
- Step 4
  - Height $_{Tank}$ = 72 in. = 6 ft. 6 ft. = D + ½D = 4 ft.+ 2 ft.
  - Height $_{Resin}$ = 4 ft. Height $_{F.B.}$ = 2 ft.
  - V resin = 3.14 x 1.5 x 1.5 x 4 = <u>28.26 cu. ft.</u>
  - V Freeboard = 3.14 x 1.5 x 1.5 x 2 = 14.13 cu ft = <u>105.7 gallons</u>