2013 Revised DW Module 25: Hypochlorite
Answer Key

Exercise for Unit 1 – Background and Properties

1. List and explain two uses of hypochlorite.

ANS: Answers may include disinfection, oxidation, and control of taste and odor.

2. Matching: Please match the chemical with the available chlorine by weight by drawing lines between the matches:

Chemical	**Available Chlorine by Weight**
Sodium hypochlorite	0.1 %
Household bleach	5.25%
Calcium hypochlorite	12 to 15%
	65 to 70%

3. Which of the following affect the stability of hypochlorite:
   a. Temperature
   b. Color
   c. Exposure to light
   d. How long it is stored

   Answer: a, c, and d.

4. Circle the choice that best fills in the blank:
   - The higher / lower the concentration of sodium hypochlorite, the more stable it is.
     - **Answer = lower**
   - Chlorine is less effective as the temperature decreases / increases .
     - **Answer = decreases**

- Chlorine is less effective as the pH decreases / increases .
  - **Answer = increases**

5. Dry calcium hypochlorite will lose ___**3**__ to __**5**__ percent available chlorine per year.
6. All hypochlorite solutions will release oxygen gas as the solution decomposes.

   a. True______ b. False______

   Answer = True

Exercise for Unit 2 – Storage, Handling and Safety

1. Sodium hypochlorite should not be stored longer than ____**45**___ days since its strength decomposes in storage.
2. Calcium hypochlorite should be stored in its ___**original**___ containers until it is used.
3. Hypochlorites decompose and release ___**chlorine gas**__ into the air.
4. Forced air ventilation should be turned on whenever workers enter the hypochlorite storage or work area. a. True ___**X**____ b. False _________
5. MSDS is an abbreviation for **Material Safety Data Sheet.**
6. Typical information in a MSDS includes:

   a. The product name and its synonyms.

   b. Fire and explosion hazard data.

   c. Toxicity data.

   d. First aid procedures.

   e. All of the above. **This is the correct answer.**

7. Hypochlorite spills should be washed with large amounts of ___**water**_____ to dilute it.
8. Hypochlorite will react spontaneously with organic material and should be kept separate from all organic compounds such as: fats, sugar, oils, turpentine, and other oxidizable materials.

   a. True __**X**___

   b. False ______

9. First aid procedures for skin contact with hypochlorite include showering with large quantities of __**water**____ and calling for medical assistance.

10. Hypochlorite should be stored so that it does not get direct exposure to **answers could include water, heat, direct sunlight, and organic matter.**

Unit 3 – Chemical Feed

Class Activity - Fractions Written in Vertical Format:

ANS:

1/8 = $\frac{1}{8}$ **(The numerator is: 1)**

2/6 = $\frac{2}{6}$ **(The denominator is: 6)**

$\frac{8}{10}$ **means that 8 is divided by 10**

Explanation of diagonal movement and an example:

Example 1:

5X = 20

Question #1 regarding Example #1: Is the ***X*** in the numerator? **YES**
Question #2 regarding Example #1: Is the ***X*** alone on one side of the equation? **NO**
How do we use diagonal movement to place ***X*** alone on one side of the equation?

Answer:

- Divide both sides by "5" to get ***X*** alone and **treat both sides of the equation equally**. Notice that the 5 was moved from the top of the left side to the bottom of the right side of the equation – **a diagonal move.**

$\frac{\cancel{5}\mathbf{X}}{\cancel{5}} = \frac{20}{5}$

FINAL ANSWER: 20 ÷ 5 = 4

Example 2:

$$2.5 = \frac{1{,}000}{\boldsymbol{X}}$$

Question #1 regarding Example #2: Is the ***X*** in the numerator? **NO**
How do we move the ***X*** into the numerator?
Answer:

- Multiply both sides of the equation by ***X***. Or, you could think of it as simply moving the ***X*** diagonally from the denominator into the numerator.

$$\boldsymbol{X}(2.5) = \frac{1{,}000\cancel{(\boldsymbol{X})}}{\cancel{\boldsymbol{X}}}$$ **OR** $$\boldsymbol{X}(2.5) = \frac{1{,}000}{\boldsymbol{X}}$$

Question #2 regarding Example #2: Is the ***X*** alone on one side of the equation? **NO**
How do we use diagonal movement to place ***X*** alone on one side of the equation?

Answer:

- Divide by 2.5 on each side of the equation so that the ***X*** is alone, but the equation keeps the same value

$$\frac{\boldsymbol{X}\cancel{(2.5)}}{\cancel{2.5}} = \frac{1{,}000}{2.5}$$

$$\boldsymbol{X} = \frac{1{,}000}{2.5}$$

FINAL ANSWER: 1,000 ÷ 2.5 = 400

Class Exercise Solving for *X*:

$$\frac{\boldsymbol{X}}{200} = 2.4$$

$$\boldsymbol{X} = 2.4(200)$$

$$\boldsymbol{X} = 480$$

$$10 = \frac{3000}{\boldsymbol{X}}$$

$$\frac{X\cancel{(10)}}{\cancel{(10)}} = \frac{3000}{10}$$

$$\boldsymbol{X} = 300$$

Class Exercise: Explanation of the Order of Operation

Example 2:

(***X***)(2)(8.34) = 500

Step #1: Simplify terms by **multiplying and dividing** from left to right within parentheses.

(***X***)16.68 = 500

Step # 2: Verify that the X term is in the numerator. If it is not, move the ***X*** term to the numerator, using a diagonal move.

Is X in the numerator YES

Step #3: Verify that ***X*** is by itself, on one side of the equation. If it is not, divide both sides of the equation by the number on the ***X*** side of the equation.

Does this equation require a division? YES If so by what number? 16.68

$$\frac{(X)\cancel{16.68}}{\cancel{16.68}} = \frac{500}{16.68}$$

FINAL ANSWER: 500 ÷ 16.68 = 29.97

Practice Problem: Steps to solving problems using unit cancellation

Practice Problem:

How many hours will it take to empty a 55 gallon drum of sodium hypochlorite using a chemical feed pump that's pumping at a rate of 30 mL/min?

Solution:

Unknown Data: ? Hours Known Data: $\frac{55\text{ gal}}{1}$ and $\frac{30\text{ mL}}{1\text{ min}}$

Positions the numerator

Known

Known

$$\frac{?\text{ Hours}}{1} = \frac{1\text{ hr}}{60\ \cancel{\text{mins}}} \times \frac{1\ \cancel{\text{min}}}{30\ \cancel{\text{mL}}} \times \frac{3785\ \cancel{\text{mL}}}{\cancel{\text{gal}}} \times \frac{55\ \cancel{\text{gal}}}{1} = \frac{208175}{1800} = 115.6\text{ hrs.}$$

Conversion

Conversion

Note: The pump rate is rearranged to place the time unit in the numerator.

ANS: 115.6 hours

Practice Problem: Calculations for Changing % Concentrations of a Chemical

Practice Problem: You purchase a new pump. The old pump fed 5.5 gallons daily of 15% sodium hypochlorite. You need to change your concentration to a 6% solution. How many gallons can you now expect to use each day?

Step 1: Set up math equation: 5.5 gal x 15% = ? gal x 6%

Step 2: Divide both sides by 6% to get **? gal** alone on the right side of the equation

5.5 gal x 15~~%~~ = ? gal x ~~6%~~
6 ~~%~~ ~~6%~~

Step 3: Multiply 5.5 x 15 = 82.5 in the numerator

Step 4: Perform the division: 82.5 (numerator) ÷ 6 (denominator) = 13.75 gallons

Vertical Format of Step 4: 82.5
6

Practice Problem: Feed Rate Calculations Using Flow with a % Strength (i.e., % pure) Solution

Practice Problem: A water plant uses sodium hypochlorite (15%) to disinfect the water. The target dose is 1.6 mg/L. They treat 0.25 million gallons per day. How many pounds of sodium hypochlorite will need to be fed?

Step 1: Solve for pounds per day (feed rate) for 100 % pure chemical (no impurities).

Using the formula pounds per day = flow x dose x 8.34 = (0.25)(1.6)(8.34) = 3.3 pounds of chlorine is required.

Step 2: Calculate # of pounds of 15% solution needed to achieve Step 1 feed rate.

a) Convert % purity of solution into a decimal:

15 % = 0.15
100%

b) Then divide the pounds needed (feed rate of 100% pure chemical) by the % purity of the solution (as a decimal).

3.3 pounds = 22 pounds of 15% hypochlorite.
0.15 (% purity as a decimal)

TIP: Answer will always be more pounds than Step 1 result because solution is not 100% pure.

Practice Problems: Feed Rate Problem Using Volume instead of Flow with a % Strength (i.e., % Purity) Chemical

Practice Problem #1

Calculate the amount of calcium hypochlorite to dose a 500,000 gallon storage tank to a dose of 25 mg/L using granular calcium hypochlorite that indicates it is 65% chlorine.

Step 1: Convert volume (in gallons) into MG so that the feed rate (lbs) formula can be used.

$$?MG = \frac{1\ MG}{1{,}000{,}000\ gal} \times (500{,}000)\ gal = 0.5\ MG$$

Step 2: Solve for pounds per day (feed rate) for 100 % pure chemical (no impurities).

? lbs = volume(MG) x dose(mg/L) x 8.34 = (0.5)(25)(8.34) = 104.25 pounds of chlorine is required.

Step 3: Calculate # of pounds of 65% solution needed to achieve Step 2 feed rate.

a) Convert % purity of solution into a decimal:

$$\frac{65\%}{100\%} = 0.65$$

b) Then divide the pounds needed (feed rate of 100% pure chemical) by the % purity of the solution (as a decimal).

$$\frac{104.25\ pounds}{0.65} = 160.39$$ pounds of 65% calcium hypochlorite.

Practice Problem #2:

Calculate the amount of chlorine required for a dosage of 1 mg/L in a 600,000 gallon storage tank. The tank is **¾ full**. (Assume 100% strength)

Step 1: Calculate volume of tank that is not 100% full by multiplying the volume by the fraction (or its equivalent decimal.)

$600{,}000 \times \frac{3}{4} = 450{,}000$ gallons OR $600{,}000 \times 0.75 = 450{,}000$ gallons

Step 2: Convert volume (in gallons) into MG so that the feed rate (lbs) formula can be used.

$$?MG = \frac{1\ MG}{1{,}000{,}000\ \cancel{gal}} \times 450{,}000\ \cancel{gal} = 0.45\ MG$$

(continued on next page)

Step 3: Solve for pounds per day (feed rate) for 100 % pure chemical (no impurities).

? lbs = volume(MG) x dose(mg/L) x 8.34 = (.45)(1)(8.34) = 3.75 pounds of chlorine is required.

Practice Problem: Using "Active Ingredient Weight to Convert Feed Rate from lbs/day to gallons/day

Practice Problem: A water plant uses sodium hypochlorite (12.5%) to disinfect the water which provides 1.2 lbs/gal of available chlorine ("active ingredient" weight). The chlorine dosage is 1.6 mg/L. They treat 600,000 gallons per day. How many gallons of sodium hypochlorite will need to be fed?

Step 1: Convert flow in gallons (per day) into MGD so that the feed rate (lbs/day) formula can be used.

$$? \text{ MGD} = \frac{1 \text{ MG}}{1{,}000{,}000 \ \cancel{\text{gal}}} \ \text{X} \ \frac{600{,}000 \ \cancel{(\text{gal})}}{1 \ \text{day}} = 0.6 \text{ MGD}$$

Step 2: Solve for pounds per day (feed rate) for 100 % pure chemical (no impurities).

Using the formula pounds per day = flow x dose x 8.34 = (0.6)(1.6)(8.34) = 8 pounds of chlorine is required.

Step 3: Use "active ingredient" weight with unit cancellation steps to convert lbs/day to **gal/day**

Active Ingredient Weight of 12.5% hypo solution

Feed Rate

$$? \frac{\text{gal}}{\text{day}} = \frac{1 \text{ gallon}}{1.2 \text{ lbs}} \ \text{x} \ \frac{8 \ \text{lbs}}{\text{day}} = \frac{6.67 \text{ gal}}{\text{day}}$$

NOTE: When you are given the "active ingredient" weight of a solution to solve a feed rate problem, you do not need to use the % purity factor because it was used in the weight calculation.

Practice Problem: Equation #2: Solving for Flow Using the Feed Rate Formula

Practice Problem: A water treatment plant uses 8 pounds of chlorine daily and the dose is 17 mg/L. How many gallons are they producing?

Step 1: Set up the variables in vertical format and insert known values

$$? \text{ Flow (MGD)} = \frac{\text{Feed Rate, lbs/day}}{\text{(Dose)(8.34)}} = \frac{(8)\text{ lb/day}}{(17)(8.34)}$$

Step 2: Multiply 17 x 8.34 in the denominator = 141.78 (basic math rule)

Step 3: Perform the **FLOW** division: 8 (numerator) ÷ 141.78 (denominator) = 0.056425 MGD

Unit Cancellation Steps to solve for gallons/day

$$? \frac{\text{gallons}}{\text{day}} = \frac{1{,}000.000 \text{ gallons}}{1 \cancel{\text{MG}}} \times \frac{.056425 \cancel{\text{MG}}}{\text{day}} = 56{,}425 \frac{\text{gallons}}{\text{day}}$$

Practice Problem: Equation #3: Solving for Dose Using the Feed Rate Formula

Practice Problem: A water treatment plant produces 150,000 gallons of water every day. It uses an average of 2 pounds of permanganate for iron and manganese removal. What is the dose of the permanganate?

Step 1: Set up the variables in vertical format.

$$? \text{ Dose (mg/L)} = \frac{\text{Feed Rate, lbs/day}}{\text{(Flow, MGD)(8.34)}}$$

Step 2: Convert gallons per day into MGD and insert known values into equation.

$$? \frac{\text{MG}}{\text{day}} = \frac{1 \text{ MG}}{1{,}000{,}000 \cancel{\text{gallons}}} \times \frac{150{,}000 \cancel{\text{gallons}}}{\text{day}} = 0.15 \text{ MGD}$$

$$? \text{ Dose (mg/L)} = \frac{\text{Feed Rate, lbs/day}}{\text{(Flow, MGD)(8.34)}} = \frac{(2)\text{ lb/day}}{(0.15)(8.34)}$$

Step 3: Multiply 0.15 x 8.34 in the denominator = 1.25 (basic math rule)

Step 4: Perform the **DOSE** division: 2 (numerator) ÷ 1.25 (denominator) = 1.6 $\frac{\text{mg}}{\text{L}}$

Practice Problem: Calculating feed rate for a work shift (less than 24 hours)

Practice Problem: You must maintain 0.5 mg/L chlorine residual in the finished water with a chlorine demand of 1.5 mg/L. The pumping rate is 300 gpm. How many pounds of 65% calcium hypochlorite will be fed during 12 hours?

Step 1: Calculate the dose using the formula

Chlorine Dose (mg/L) = Chlorine Demand (mg/L) + Chlorine Residual (mg/L)

Dose = 1.5 + 0.5
= 2.0 mg/L

Step 2: Convert gpm to MGD

$$?\frac{MG}{day} = \frac{1\ MG}{1{,}000{,}000\ \cancel{gal}} \times \frac{300\ \cancel{gal}}{\cancel{min}} \times \frac{1440\ \cancel{min}}{day} = 0.432\ MGD$$

Step 3: Use Feed Rate calculation to solve for lb/day

? lbs/day = flow x dose x 8.34 = (0.432)(2.0)(8.34) = 7.2 pounds of chlorine is required.

Step 4: Calculate # of pounds of 65% solution needed to achieve Step 3 feed rate.

a) Convert % purity of solution into a decimal:

$$\frac{65\%}{100\%} = 0.65$$

b) Then divide the pounds needed (feed rate of 100% pure chemical) by the % purity of the solution (as a decimal).

$$\frac{7.2\ pounds}{0.65} = 11$$ pounds of 65% calcium hypochlorite.

Step 5: Calculate pounds needed for 12 hours

$$?lbs = 11\ \frac{lbs}{day} \times \frac{1\ \ day}{24\ hrs} \times \frac{12\ hrs}{1} = 5.5\ lbs$$ in 12 hours

Practice Problem: Calculating Feed Rate and Converting to gallons per day

Practice Problem: How many gallons of 12% sodium hypochlorite are required to treat 150,000 gpd with a desired residual of 0.8 mg/L and a chlorine demand of 0.6 mg/L? NOTE: 12% sodium hypochlorite – 1.2 lb/gallon available chlorine ("active ingredient" weight).

Step 1: Calculate the dose using the formula

Chlorine Dose (mg/L) = Chlorine Demand (mg/L) + Chlorine Residual (mg/L)

Dose = 0.8+ 0.6
= 1.4 mg/L

Step 2: Convert gpd to MGD

$$\frac{150{,}000}{1{,}000{,}000} = 0.15 \text{ MGD}$$

Step 3: Use Feed Rate calculation to solve for lbs/day

? lbs/day = flow x dose x 8.34 = (0.15)(1.4)(8.34) = 1.75 pounds of chlorine is required.

Step 4: Use "active ingredient" weight with unit cancellation steps to convert lbs/day to gallons/day

Active Ingredient Weight of 12% hypo solution

100 % Feed Rate

$$?\frac{\text{gal}}{\text{day}} = \frac{1 \text{ gallon}}{1.2 \text{ lbs}} \times \frac{1.75 \text{ lbs}}{\text{day}} = \frac{1.46 \text{ gal}}{\text{day}}$$

Practice Problem: Calculating CT

Practice Problem: If a free chlorine residual of 2.5 mg/L is measured at the end of the clearwell after 4 hours of detention time, what is the CT value in mg-min/L?

Step 1: Convert detention time from hours to minutes.

$$? \text{ Min} = \frac{60 \text{ min}}{\text{hr}} \times 4 \text{ hr} = 240 \text{ minutes}$$

Step 2: Insert disinfectant residual concentration and contact time (in minutes) into CT equation and multiply the values.

CT = 2.5 mg/L x 240 minutes = 600 mg-min/L

Practice Problem: Calculating Theoretical Detention Time

Practice Problem: What is the detention time (in min) of a tank that has a volume of 150,000 gallons with a plant flow rate of 2.5 MGD? (hint: convert the flow rate to gpm, then plug into DT)

Step 1: Convert flow rate from MGD to gpm

$$?\frac{\text{gal}}{\text{min}} = \frac{1{,}000{,}000 \text{ gal}}{1 \cancel{\text{MG}}} \times 2.5 \frac{\cancel{\text{MG}}}{\cancel{\text{day}}} \times \frac{1 \cancel{\text{day}}}{1440 \text{ mins}} = 1736 \frac{\text{gal}}{\text{mins}}$$

Step 2: Calculate detention time using the formula:

$$\text{Detention Time (time)} = \frac{\text{Volume}}{\text{Flow}} \qquad \frac{150{,}000 \text{ gallons}}{1736 \text{ gpm}} = 86 \text{ minutes}$$

Practice Problem: Calculating Detention Time and CT

Practice Problem: A plant is set at a flow rate of 3 MGD. Water enters into a clearwell that has a volume of 50,000 gallons. The chlorine residual of the outlet end of the tank is 1.6 mg/L. What is the CT in mg-min/L?

Step 1: Convert flow rate from MGD to gpm

$$\frac{?\text{gal}}{\text{min}} = \frac{1{,}000{,}000 \text{ gal}}{1 \cancel{\text{MG}}} \times \frac{3 \cancel{\text{MG}}}{\cancel{\text{day}}} \times \frac{1 \cancel{\text{day}}}{1440 \text{ mins}} = \frac{2083 \text{ gal}}{\text{mins}}$$

Step 2: Calculate detention time using the formula:

$$\text{Detention Time (time)} = \frac{\text{Volume}}{\text{Flow}} \qquad \frac{50{,}000 \text{ gallons}}{2083 \text{ gpm}} = 24 \text{ minutes}$$

Step 3: Insert disinfection residual concentration and contact time (in minutes) into CT equation and multiply the values.

CT = 1.6 mg/L x 24 minutes = 38 mg-min/L

Exercise for Unit 3 – Chemical Feed Dosage, Chlorine Demand and CT Calculations

1. In order to use the Feed Rate formula which is lbs/day = Flow or Volume x Dosage x 8.34, name the units of measurement for the flow or volume:

   a) MGD or MG

   b) gpm

   c) gpd

   d) All of the above units can be used

2. If you have calculated the feed rate for a solution as if it's 100% pure; but, your solution is a 65% calcium hypochlorite, what value do you use to represent the percent purity (as a decimal)? In other words, what value are you dividing by?

   a) 65

   b) 6.5

   c) 0.65

   d) 0.0065

3. You have determined that you need to feed 100 lbs/day of chlorine. You are using 15% sodium hypochlorite which provides 1.2 lbs/gal available chlorine. In order to convert the “lbs/day” feed rate into “gallons/day,” what math step do you use?

    a) 100 lbs/day X 1.2 lbs/gal

    b) 100 lbs/day X 0.15

    c) 100 lbs/day ÷ 1.2 lbs/gal

    d) 100 lbs/day ÷ 0.15

4. When calculating a CT value, what units are used in the detention time calculation?

    a) Volume (MG) ÷ Flow (gpm)

    b) Volume (Gal) ÷ Flow (gpm)

    c) Volume (MG) ÷ Flow (MGD)

    d) Volume (Gal) ÷ Flow (MGD)

Exercise for Unit 4 – Chemical Feed

1. The disinfection process for surface water supplies must achieve 99.9 percent (3 log) inactivation of Giardia cysts and 99.99 percent (4 log) inactivation of enteric viruses.

2. Chlorine residual samples are taken at representative points within the distribution system. These samples are taken at the same time and at the same location as the coliform samples are taken.

    a. __X____ True
    b. ______ False

3. The **maximum residual disinfectant level (MRDL)** is the maximum permissible level of a disinfectant added for water treatment that may not be exceeded at the consumer’s tap without an unacceptable possibility of aderse health effects.

4. List one way a water supplier can reduce THM formation:

Any of the following:

- Reduce the organic material before chlorinating the water. Treatment techniques, such as coagulation, sedimentation, and filtration can remove most of the organic materials. However, activated carbon can be used to remove greater amounts of organic material than can be removed by other techniques.
- Optimize chlorine usage.
- Change the point of chlorine addition in the treatment series. If the point of chlorine addition is moved to a location **after** sedimentation or filtration, THM production can be reduced as these processes remove part of the organic material.
- Use alternative disinfection methods. Using a mixture of chlorine and ammonia (chloramine) reduces THM formation.

5. Explain what breakpoint chlorination is.

   Breakpoint chlorination is the addition of chlorine until all chlorine demand has been satisfied. At this point, further additions of chlorine will result in a free chlorine residual that is directly proportional to the amount of chlorine added beyond the breakpoint. Breakpoint chlorination determines how much chlorine is required for disinfection.

6. The breakpoint chlorination curve can be used to determine how much chlorine is required for disinfection.

7. Chlorine dose = chlorine demand (mg/L) + chlorine residual (mg/L).

8. A day tank stores daily amounts of chemical required for delivery by feeders.

9. Calcium hypochlorite solutions are typically prepared with a 1 to 3 % strength.

10. A pump calibration curve plots feed rate delivery versus the pump setting.

11. In the event of an abnormal operation, be sure to inform your Supervisor about the problem.

Appendix Hypochlorite Practice Math Problems

Hypochlorite Practice Math Problems

1. **In 24 hours, 4.2 gallons of 12% hypochlorite solution is fed. How much (in gallons) would you have to use if the concentration was 7%?**
   a. 2.4 gallons
   b. 5 gallons
   c. 7.2 gallons
   d. 10.1 gallons

Step 1: Set up math equation: 4.2 gal X 12% = ? x 7%

Step 2: Divide both sides by 7% to get **? gal** alone on the right side of the equation

$$\frac{4.2\text{ gal} \times 12\%}{7\%} = ?\text{ gal} \times \frac{\cancel{7\%}}{\cancel{7\%}}$$

Step 3: Multiply 4.2 X 12 = 50.4 in the numerator

Step 4: Perform the division: 50.4 ÷ 7 = 7.2 gallons See 3-12 WB for complete explanation

2. **In 10 hours, you feed 3.5 gallons of 12.5% hypochlorite solution. How many gallons would you have to use if the concentration is 6%?**
   a. 7.3 gallons
   b. 3.7 gallons
   c. 1.4 gallons
   d. 0.9 gallons

Step 1: Set up math equation: 3.5 gal X 12.5% = ? x 6%

Step 2: Divide both sides by 6% to get **? gal** alone on the right side of the equation

$$\frac{3.5\text{ gal} \times 12.5\cancel{\%}}{6\cancel{\%}} = ?\text{ gal} \times \frac{\cancel{6\%}}{\cancel{6\%}}$$

Step 3: Multiply 3.5 X 12.5 = 43.75 in the numerator

Step 4: Perform the division: 43.75 ÷ 6 = 7.3 gallons

See 3-12 WB for complete explanation

3. **A plant flow is set at 2.2 MGD. The chlorine dose needs to be 2.0 mg/L. How many pounds of 12.5% sodium hypochlorite can the system expect to use each day?**
    a. 294 pounds
    b. 37 pounds
    c. 0.3 pounds
    d. 30 pounds

Step 1: Solve for feed rate of 100% pure chemical by using lbs/day = (2.2) (2.0) (8.34) = 36.69

Step 2: Calculate # of pounds of 12.5% by dividing Step 1 feed rate by purity as a decimal:

$$\frac{36.69 \text{ pounds}}{0.125} = 293.5 \text{ pounds}$$ of 12.5% sodium hypochlorite.

See 3-17 WB for complete explanation

4. **A system needs to determine how many pounds of 12.5% sodium hypochlorite they will use when the plant is set at a flow of 375,000 gpd. They need to maintain a chlorine dosage of 1.5 mg/L**.
    a. 4.7 pounds
    b. 47 pounds
    c. 37.5 pounds
    d. 3.8 pounds

Step 1: Convert gpd to MGD: 375,000 ÷ 1,000,000 = .375 MGD

Step 2: Solve for feed rate of 100% pure chemical by using lbs/day = (.375) (1.5) (8.34) = 4.69

Step 3: Calculate # of pounds of 12.5% by dividing Step 2 feed rate by purity as a decimal:

$$\frac{4.69 \text{ pounds}}{0.125} = 37.5 \text{ pounds}$$ of 12.5% sodium hypochlorite.

See 3-19 WB for complete explanation

5. **A tank contains 575,000 gallons of water. This water is to receive a chlorine dose of 2.2 mg/L. How many pounds of calcium hypochlorite (65% available) will be required for this disinfection**?
   a. 16.2 pounds
   b. 10,550 pounds
   c. 10.55 pounds
   d. .162 pounds

Step 1: Convert gpd to MGD: 575,000 ÷ 1,000,000 = .575 MGD

Step 2: Solve for feed rate of 100% pure chemical by using lbs = (.575) (2.2) (8.34) = 10.55

Step 3: Calculate # of pounds of 65% by dividing Step 2 feed rate by purity as a decimal:

$$\frac{10.55 \text{ pounds}}{0.65} = 16.2 \text{ pounds of 65\% calcium hypochlorite}$$

See 3-20 WB for complete explanation

6. **Calculate the amount of chlorine required to dose an 800,000 gallon storage tank to a dose of 5 mg/L. You believe it is best to use granular calcium hypochlorite and the product information indicates it is 68% chlorine.**
   a. 25 pounds
   b. 33 pounds
   c. 49 pounds
   d. 60 pounds

Step 1: Convert gpd to MGD: 800,000 ÷ 1,000,000 = 0.8 MGD

Step 2: Solve for feed rate of 100% pure chemical by using lbs = (0.8) (5) (8.34) = 33.36

Step 3: Calculate # of pounds of 68% by dividing Step 2 feed rate by purity as a decimal:

$$\frac{33.36 \text{ pounds}}{0.68} = 49 \text{ pounds of 68\% calcium hypochlorite.}$$

See 3-20 WB for complete explanation

7. **After cleaning, a system needs to disinfect a 750,000 gallon storage tank. The system has decided on a dose of 25 mg/L. How many pounds of 68% calcium hypochlorite would they need to purchase for the job?**
    a. 30 pounds
    b. 75 pounds
    c. 156 pounds
    d. 230 pounds

Step 1: Convert gpd to MGD: 750,000 ÷ 1,000,000 = .75 MGD

Step 2: Solve for feed rate of 100% pure chemical by using lbs = (.75) (25) (8.34) = 156.37

Step 3: Calculate # of pounds of 68% by dividing Step 2 feed rate by purity as a decimal:

$\frac{156.37 \text{ pounds}}{0.68}$ = 229.9 pounds of 68% calcium hypochlorite.

See 3-20 WB for complete explanation

8. **How many pounds of chlorine would be needed to disinfect a 700,000 gallon tank that is $^{2}/_{3}$ full? It has been determined it needs dosed to 5 mg/l.**
    a. 19.5 lbs
    b. 29.2 lbs
    c. 9.7 lbs
    d. 39.5 lbs

Step 1: Calculate volume of tank that is not 100% full by multiplying volume by the fraction (or its equivalent decimal):

700,000 X $\frac{2}{3}$ = 466200 gallons OR 700,000 x 0.66 = 466200 gallons

Step 2: Convert gpd to MGD: 466200 ÷ 1,000,000 = 0.4662 MGD

Step 3: Solve for feed rate of 100% pure chemical by using lbs = (0.4662) (5) (8.34) = 19.4 lbs

See 3-22 WB for complete explanation

9. **A treatment plant uses sodium hypochlorite (12%) to disinfect the water. The target dose is 0.8 mg/L. They treat 250,000 gpd. How many pounds of sodium hypochlorite will they need to feed?**
   a. 14 pounds
   b. 10 pounds
   c. 4.3 pounds
   d. 1.7 pounds

Step 1: Convert gpd to MGD: 250,000 ÷ 1,000,000 = 0.25 MGD

Step 2: Solve for feed rate of 100% pure chemical by using lbs/day = (0.25) (0.8) (8.34) = 1.67

Step 3: Calculate # of pounds of 12% by dividing Step 2 feed rate by purity as a decimal:

$\frac{1.67 \text{ pounds}}{0.12}$ = 13.9 pounds of 12% sodium hypochlorite.

See 3-23 WB for complete explanation

10. **A treatment plant uses 12.5% hypochlorite to disinfect the water. The required hypochlorite dosage is 2 mg/L and the plant flow is 300,000 gpd. How many gallons of 12.5% hypochlorite are required (12.5% hypo has 1.25 lbs/gal available chlorine)?**

    a. 5.1 gallons
    b. 4 gallons
    c. 12 gallons
    d. 400 gallons

Step 1: Convert gpd to MGD: 300,000 ÷ 1,000,000 = 0.30 MGD

Step 2: Solve for feed rate of 100% pure chemical by using lbs/day = (0.30) (2.0) (8.34) = 5 lbs/day

Step 3: Convert to gallons using the available chlorine (unit cancellation):

$\frac{\text{? gallons}}{\text{Day}} = \frac{1 \text{ gal}}{1.25 \text{ lbs}} \times \frac{5 \text{ lbs}}{\text{day}}$ = 4 gallons/day

See 3-25 WB for complete explanation

11. The chlorine demand of the water is 1.4 mg/L. If the desired chlorine residual is 0.5 mg/L, what is the desired chlorine dose, in mg/L?

a. 0.9 mg/L
b. 1.3 mg/L
c. 1.5 mg/L
d. 1.9 mg/L

Step 1: Dose = demand + residual (.5 + 1.4) = 1.9 mg/L
See 3-31 WB for complete explanation

12. At a flow rate of 375 gpm, how many pounds of 67% calcium hypochlorite would be required to maintain a 0.8 mg/L chlorine residual in the finished water if the chlorine demand is 0.8 mg/L?

a. 3.6 pounds
b. 5.4 pounds
c. 7.2 pounds
d. 10.8 pounds

Step 1: Calculate dose by adding demand + residual (0.8 + 0.8) = 1.6 mg/L
Step 2: Convert gpm to MGD

$$?\frac{MG}{day} = \frac{1\ MG}{1{,}000{,}000\ gal} \times 375\ \frac{gal}{min} \times 1440\ \frac{min}{day} = 0.54\ MGD$$

Step 3: Solve for feed rate of 100% pure chemical by using lbs/day = (0.54) (1.6) (8.34) = 7.2

Step 4: Calculate # of pounds of 67% by dividing Step 3 feed rate by purity as a decimal:

$\frac{7.2\ pounds}{0.67}$ = 10.8 pounds of 67% calcium hypochlorite.

See 3-32 WB for complete explanation (step 5 not needed)

13. A system needs to maintain a chlorine residual of 0.8 mg/L. The chlorine demand is 1.2 mg/L and the plant flow is set at 500 gpm. How many pounds of 65% calcium hypochlorite would the system expect use in 8 hours?

a. 12 pounds
b. 6 pounds
c. 9 pounds
d. 11 pounds

Step 1: Calculate dose by adding demand + residual (1.2 + 0.8) = 2.0 mg/L

Step 2: Convert gpm to MGD

$$?\frac{MG}{day} = \frac{1\ MG}{1{,}000{,}000\ gal} \times \frac{500\ gal}{min} \times \frac{1440\ min}{day} = 0.72\ MGD$$

Step 3: Solve for feed rate of 100% pure chemical by using lbs/day = (0.72) (2) (8.34) = 12

Step 4: Calculate # of pounds of 65% by dividing Step 3 feed rate by purity as a decimal:

$$\frac{12\ pounds}{0.65} = 18.4 \text{ pounds of 65\% calcium hypochlorite.}$$

Step 5: Calculate pounds needed for 8 hours

$$?lbs = 18.4\ \frac{lbs}{day} \times \frac{1\ day}{24\ hrs} \times \frac{8\ hrs}{1} = 6.1 \text{ lbs in 8 hours}$$

See 3-32 WB for complete explanation

14. How many gallons of 15% sodium hypochlorite (1.4 lbs/gal available chlorine) are required to treat 750,000 gpd with a desired chlorine residual of 0.8 mg/L and a demand of 0.6 mg/L?

a. 2 gallons
b. 4 gallons
c. 6 gallons
d. 8 gallons

Step 1: Calculate dose by adding demand + residual (0.8 + 0.6) = 1.4 mg/L

Step 2: Convert gpd to MGD: 750,000 ÷ 1,000,000 = 0.75 MGD

Step 3: Solve for feed rate of 100% pure chemical by using lbs/day = (0.75) (1.4) (8.34) = 8.76

Step 4: Use unit cancellation to convert lbs/day to gallons/day

Active Ingredient weight of 15% hypo solution

Feed Rate

$$?\frac{\text{gal}}{\text{day}} = \frac{1\text{ gallon}}{1.4\text{ lbs}} \times \frac{8.76\text{ lbs}}{\text{day}} = \frac{6.25\text{ gal}}{\text{day}}$$

See 3-34 WB for complete explanation

15. How many gallons of 12½% sodium hypochlorite are required to treat 750,000 gpd with a desired residual of 1.2 mg/L and a chlorine demand of 0.5 mg/L? (note, 12½% has 1.2 lbs/gal available chlorine)

a. 7 gal/day
b. 9 gal/day
c. 11 gal/day
d. 13 gal/day

Step 1: Calculate dose by adding demand + residual (0.5 + 1.2) = 1.7 mg/L

Step 2: Convert gpd to MGD: 750,000 ÷ 1,000,000 = 0.75 MGD

Step 3: Solve for feed rate of 100% pure chemical by using lbs = (0.75) (1.7) (8.34) = 10.63

Step 4: Use unit cancellation to convert lbs/day to gallons/day

Active Ingredient weight of 12.5% hypo solution

Feed Rate

$$\frac{?\text{gal}}{\text{day}} = \frac{1 \text{ gallon}}{1.2 \text{ lbs}} \times \frac{10.63 \text{ lbs}}{\text{day}} = \frac{8.8 \text{ gal}}{\text{day}}$$

See 3-34 WB for complete explanation

16. A plant is set at a flow rate of 3 MGD. Water enters into a clearwell that has a volume of 55,000 gallons. The chlorine residual of the outlet end of the tank is 1.4 mg/L. What is the CT in mg-min/L?

a. 25
b. 180
c. 37
d. 203

Step 1: Convert flow rate from MGD to gpm

$$\frac{?\text{gal}}{\text{min}} = \frac{1{,}000{,}000\text{ gal}}{1\text{ MG}} \times \frac{3\text{ MG}}{\text{day}} \times \frac{1\text{ day}}{1440\text{ mins}} = 2083.3\ \frac{\text{gal}}{\text{mins}}$$

Step 2: Calculate detention time using the formula:

$$\text{Detention Time (time)} = \frac{\text{Volume}}{\text{Flow}} \qquad \frac{55{,}000\text{ gallons}}{2083.3\text{ gpm}} = 26.4\text{ minutes}$$

Step 3: Insert disinfectant residual concentration and contact time (in minutes) into CT equation and multiply the values.

CT = disinfectant concentration x contact time

CT = 1.4 mg/L x 26.4 minutes = 36.9 mg-min/L

See 3-38 WB for complete explanation

17. A free chlorine residual of 1.7 mg/L is measured at the end of the clearwell after 4 hours of detention time, what is the CT value in mg-min/L?

a. 6.8 mg-min/L
b. 80 mg-min/L
c. 240 mg-min/L
d. 408 mg-min/L

Step 1: Convert 4 hours into minutes (4 X 60) = 240 mins

Step 2: Insert disinfectant residual concentration and contact time (in minutes) into CT equation and multiply the values.

CT = disinfectant concentration x contact time

CT = 1.7 mg/L x 240 minutes = 408 mg-min/L

See 3-36 WB for complete explanation

18. A plant is set at a flow rate of 2 MGD. Water enters into a clearwell that has a volume of 50,000 gallons. The chlorine residual of the outlet end of the tank is 0.9 mg/L. What is the CT in mg-min/L?

a. 11 mg-min/L
b. 22.5 mg-min/L
c. 32 mg-min/L
d. 44.5 mg-min/L

Step 1: Convert flow rate from MGD to gpm

$$\frac{?\,\text{gal}}{\text{min}} = \frac{1{,}000{,}000\ \text{gal}}{1\ \cancel{\text{MG}}} \times \frac{2\ \cancel{\text{MG}}}{\cancel{\text{day}}} \times \frac{1\ \cancel{\text{day}}}{1440\ \text{mins}} = \frac{1388.8\ \text{gal}}{\text{mins}}$$

Step 2: Calculate detention time using the formula:

$$\text{Detention Time (time)} = \frac{\text{Volume}}{\text{Flow}} \qquad \frac{50{,}000\ \text{gallons}}{1388.8\ \text{gpm}} = 36\ \text{minutes}$$

Step 3: Insert disinfectant residual concentration and contact time (in minutes) into CT equation and multiply the values.

CT = 0.9 mg/L x 36 minutes = 32.4 mg-min/L See 3-38 WB for complete explanation

19. If the free chlorine residual of 1.8 mg/L is measured at the end of the clearwell after 3 hour of detention time, what is the CT value in mg-min/L?

a. 5 mg-min/L
b. 75 mg-min/L
c. 176 mg-min/L
d. 324 mg-min/L

Step 1: Convert 4 hours into minutes (3 X 60) = 180 mins

Step 2: Insert disinfectant residual concentration and contact time (in minutes) into CT equation and multiply the values.

CT = disinfectant concentration x contact time

CT = 1.8 mg/L x 180 minutes = 324 mg-min/L

See 3-36 WB for complete explanation

20. If the free residual of 1.8 mg/L is measured at the entry point of the system, after 5 hours of detention time, what is the CT value in mg-min/L?

a. 16 mg-min/L
b. 95 mg-min/L
c. 275 mg-min/L
d. 540 mg-min/L

Step 1: Convert 4 hours into minutes (5 X 60)= 300 mins

Step 2: Insert disinfectant residual concentration and contact time (in minutes) into CT equation and multiply the values.

CT = disinfectant concentration x contact time

CT = 1.8 mg/L x 300 minutes = 540 mg-min/L

See 3-36 WB for complete explanation

21. In 18 hours, you use 6 gallons of 15% sodium hypochlorite. How much (gallons) would you have to use if the concentration is 7%.

a. 3 gallons
b. 10 gallons
c. 13 gallons
d. 16 gallons

Step 1: Set up math equation: 6 gal X 15% = ? x 7%

Step 2: Divide both sides by 7% to get ? gal alone on the right side of the equation

$$\frac{6\text{ gal} \times 15\%}{7\%} = ?\text{ gal} \times \frac{\cancel{7\%}}{\cancel{7\%}}$$

Step 3: Multiply 6 X 15 = 90 in the numerator

Step 4: Perform the division: 90 ÷ 7 = 12.8 gallons

See 3-12 WB for complete explanation

22. A system is using 12.5% sodium hypochlorite to disinfect at a dose of 1.5 mg/L. When the plant flow is set at 550,000 gpd, how many pounds of sodium hypochlorite should they expect to use?

a. 7 pounds
b. 35 pounds
c. 55 pounds
d. 155 pounds

Step 1: Convert gpd to MGD: 550,000 ÷ 1,000,000 = 0.55 MGD

Step 2: Solve for feed rate of 100% pure chemical by using lbs/day = (0.55) (1.5) (8.34) = 6.89

Step 3: Calculate # of pounds of 12.5% by dividing Step 2 feed rate by purity as a decimal

$$\frac{6.89}{0.125} = \text{55 lbs of 12.5\% sodium hypochlorite.}$$

See 3-23 WB for complete explanation