# DW Module 21:
# Chemical Addition
# Answer Key- Revised 2022

**Unit 1 Activity — pH Adjustment:**

| If you add | | The pH will be: |
|---|---|---|
| Potassium hydroxide | K**OH** | **Raised** |
| Nitric Acid | **H**$NO_3$ | **Lowered** |
| Calcium Hydroxide<br>Hydrated Lime | Ca(**OH**)$_2$ | **Raised** |
| Calcium Hydroxide<br>Slaked Lime | Ca(**OH**)$_3$ | **Raised** |
| Sulfuric Acid | $\mathbf{H_2}SO_4$ | **Lowered** |
| Sodium Hydroxide<br>AKA: Caustic Soda | Na**OH** | **Raised** |
| Soda Ash | $Na_2CO_3$ | **Raised** |
| Hydrochloric Acid | **H**Cl | **Lowered** |

☑ **Unit 1 Exercise:**

Fill in the blank:

1. **Coagulation:** The clumping together of very fine particles into larger particles (floc) caused by the use of chemicals. The chemicals destabilize the fine particles.

2. **Coagulant aids:** Add density to slow settling flocs and toughness to the flocs so that they will not break up during the mixing and settling process.

3. **pH:** an expression of the intensity of the basic or acidic condition of a liquid.

4. **Alkalinity**: The capacity of a water to neutralize acids.

5. **Calcium** and **Magnesium** may cause excessive hardness therefore water may need softened.

6. **Sequestering agents**: Keep iron, manganese, and calcium in solution thereby preventing the formation of precipitates.

7. **Primary disinfection** achieves the desired level of microorganism kill or inactivation.

8. **Secondary Disinfection** maintains a disinfectant residual in the finished water that prevents the regrowth of microorganisms.

9. Complete the following table indicating if the pH will be raised or lowered

| ***If you add:*** | ***The pH will be raised or lowered*** |
|---|---|
| 1. NaOH | **Raised** |
| 2. Aluminum Sulfate | **Lowered** |
| 3. Ca $(OH)_2$ | **Raised** |
| 4. Sulfuric Acid | **Lowered** |
| 5. $H_2SiF_6$ | **Lowered** |
| 6. Ferric Chloride | **Lowered** |
| 7. $Na_2CO_3$ | **Raised** |

Use the Chemical Usage Table to complete questions 10 and 11:

10. List the chemicals you might add to control odor. Include the chemical name and best feeding form for each.

**Ans:**

a. **Activated Carbon - Dry to form slurry**
b. **Ozone – Gas**
c. **Pot Permanganate - Dry to form solution**
d. **Sodium Chlorite - Dry or solution**
e. **Chlorine – Gas**
f. **Sodium Hypochlorite – Solution**

11. Name several chemicals which might be added during the coagulation process. Include examples of coagulants and other chemicals that will change the water characteristics to promote coagulation.

**Ans:**

a. **Aluminum Sulfate - Coagulant**
b. **Ferric Chloride - Coagulant**
c. **Ferric Sulfate - Coagulant**
d. **Poly Aluminum Chloride -Coagulant**
e. **Calcium Hydroxide-pH Adjustment**
f. **Calcium Oxide - pH Adjustment**
g. **Sodium Bicarbonate - pH Adjustment**
h. **Sodium Carbonate - pH Adjustment**
i. **Sodium Hydroxide - pH Adjustment**
j. **Polymers - Coagulant Aid**

## ☑ Unit 2 Activity — Reading an SDS:

1. True or **False** – Fluorosilicic acid is an eye and skin irritant, but does not affect the respiratory system.
2. Is fluorosilicic acid flammable? Yes / **No**
3. Protective clothing and equipment to be worn when handling fluorosilicic acid includes which of the following?:
    - **a. Rubber apron**
    - **b. Nitrile gloves**
    - **c. Face shield**
    - d. Dust mask
4. What is the specific gravity of fluorosilicic acid? **1.2**
5. Which of the following is fluorosilicic acid incompatible with?
    - **a) Metals**
    - b) PVC
    - **c) Glass**
    - **d) Ceramics**

## ☑ Exercise

1. Operators are expected to keep a copy of each **<u>Safety Data Sheet</u>** with regard to each of the hazardous chemicals used at their treatment facility.

2. List the three basic types of warning signs used and an example of how it will alert employees to hazardous conditions.

| Sign | Alert |
|---|---|
| **1. Warning Sign** | **Corrosive** |
| **2. Regulatory Sign** | **No Smoking** |
| **3. Pictorial Sign** | **Goggles** |

3. What types of protective clothing may be used with the various chemicals handled? Circle all that apply.

**A. Boots**

B. **Gloves**

C. **Apron**

D. **Goggles**

E. **Face Shield**

4. List 3 components of a good Emergency Response Plan

A. **Contact Information**

B. **Assessment of Available Resources**

C. **Corrective Actions for Probable Emergency Situations**

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### Example 3.1 – Detention Time Calculation

A sedimentation tank holds 50,000 gallons and the flow into the plant is 500 gpm. What is the detention time in minutes?

$$\text{Detention Time (time)} = \frac{\text{Volume}}{\text{Flow}} = \frac{50{,}000 \text{ gallons}}{500 \text{ gpm}} = \mathbf{100 \text{ minutes}}$$

### Example 3.2 – Detention Time Calculation

A tank is 20 feet by 35 feet by 10 feet. It receives a flow of 650 gpm. What is the detention time in minutes?

1. First must find volume (in gallons) then plug into Detention Time formula.
   Volume = L x W x H 20 feet x 35 feet x 10 feet = 7,000 $ft^3$

2. Convert to gallons from $ft^3$

$$\text{gallons} = 7{,}000 \, \cancel{ft^3} \times \frac{7.48 \text{ gallons}}{\cancel{ft^3}} = 52{,}360 \text{ gallons}$$

3. Plug into: Detention Time (time) $= \frac{\text{Volume}}{\text{Flow}} = \frac{52360 \text{ gallons}}{650 \text{ gpm}}$

$$= \mathbf{81 \text{ minutes}}$$

### Example 3.3 – Detention Time Calculation

A flash mix chamber has a volume of 450 gallons. The plant flow is set at 5 MGD. What is the detention time of the flash chamber in seconds? (Assume the flow is steady and continuous).

1. First, it is best to convert the flow rate from MGD to gps.

   a. 5 MGD = 5,000,000 gpd

   b. $$\frac{5{,}000{,}000\ \text{gal}}{\cancel{\text{day}}} \times \frac{\cancel{\text{day}}}{1440\ \cancel{\text{min}}} \times \frac{\cancel{\text{min}}}{60\ \text{seconds}} = \frac{58\ \text{gallons}}{\text{second}}$$

2. Plug into: Detention Time (time) $= \frac{\text{Volume}}{\text{Flow}} = \frac{450\ \text{gallons}}{58\ \text{gps}}$

   **= 8 seconds**

**Example 3.4 – Detention Time Calculation**

A water treatment plant treats a flow of 1.5 MGD. It has 2 sedimentation basins, each 20 feet wide by 60 feet long, with an effective water depth of 12 feet. Calculate the Theoretical Sedimentation Detention Time with both basins in service (in hours).

1. Step 1, find the volume of the two tanks. Note: to use the formula you have to have the volume in gallons. So, what is the volume of the tanks in gallons?

   Volume of something rectangular: L x W x D

   60 ft x 20 ft x 12 ft = 14,400 $ft^3$

   You have two tanks to take into account

   $$\begin{array}{r} 14{,}400\ ft^3 \\ \underline{\times\ \ 2} \\ 28{,}800\ ft^3 \end{array}$$

   You have to convert to gallons 28,800 $ft^3$ x 7.48 = 215,424 gallons

2. Step 2, the flow cannot be in million gallons. Keep the *DAY* units. Convert from MGD to gpd to find our detention time in days. How do we do that? So, MGD to GPD – multiply by 1,000,000.

   1.5 x 1,000,000 = 1,500,000 gpd

3. Step 3, plug our volume and our flow into the detention time formula.

$$D.T = \frac{\text{Volume of Tank}}{\text{Flow}} = \frac{215{,}424 \text{ gallons}}{1{,}500{,}000 \text{ gpd}} = 0.14 \text{ days}$$

4. Last step, convert to hours.

$$\text{Hours} = 0.14 \text{ days} \times \frac{24 \text{ hours}}{\text{day}} = 3.4 \text{ hours}$$

**So, the theoretical detention time of the sedimentation tanks at a plant flow of 1.5 MGD is 3.4 hours.**

**Example – Example Dry Feed Solution Tank Mixing**

How many pounds of dry chemical must be added to a 50 gallons day tank to produce a 0.5% solution?
*Hint: Every gallon of water weighs 8.34 pounds.*

$$? \text{ lbs} = \frac{8.34 \text{ pounds}}{\text{gallon}} \times 50 \text{ gallons} \times 0.005 = \mathbf{2.1 \text{ pounds}}$$

**Example – Example Dry Feed Solution Tank Mixing**

How many pounds of dry chemical must be added to a 35 gallon tank to produce a 2% solution?

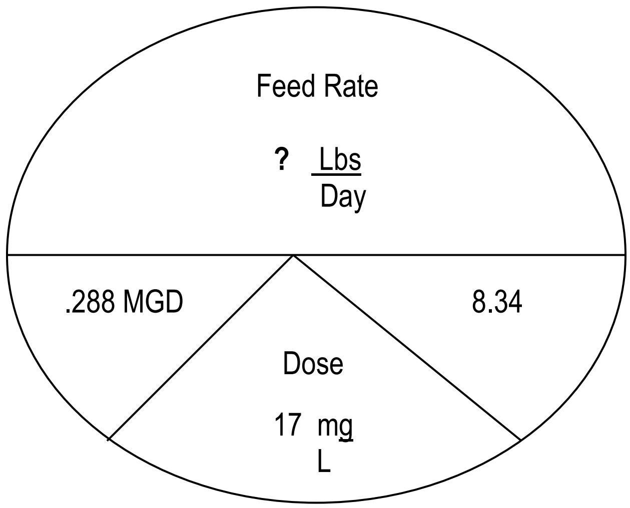
$$? \text{ lbs} = \frac{8.34 \text{ pounds}}{\text{gallon}} \times 35 \text{ gallons} \times 0.02 = \mathbf{5.8 \text{ pounds}}$$

### ☑ Example – Example Dry Feed Rate Calculation

How many pounds of lime are needed for a desired dosage of 17 mg/L when the average daily plant flow is 200 GPM?

200 GPM – must convert to MGD

$\frac{200 \times 1440}{1,000,000} = .288$




$$\text{Chemical Feed Rate in } \frac{\text{Pounds}}{\text{Day}} = \text{Plant Flow in MGD} \times \text{Dosage } \frac{\text{mg}}{\text{L}} \times 8.34$$

$$= 0.288 \text{ MGD} \times 17 \frac{\text{mg}}{\text{L}} \times 8.34$$

$$40.8 \frac{\text{lb}}{\text{day}}$$

What would the feeder output be in lb/hour?

$$\frac{\text{lb}}{\text{hr}} = 40.8 \frac{\text{lb}}{\text{day}} \times \frac{1 \text{ day}}{24 \text{ hour}} = \mathbf{1.6 \frac{lbs}{hr}}$$

**This is 100% strength dry chemical.**

## Calculating the Weight of the "Active ingredient" of a % Solution Chemical

**Practice Problem**: How many pounds of caustic soda are there in a gallon of caustic soda that is 25% pure that has a specific gravity of 1.28?

**Step 1: Solve weight equation (lbs/gal) for 1 gallon of chemical**

Weight, lbs/gal = (Specific gravity of substance) x (weight of a gallon of water)

$$1.28 \times 8.34 \frac{\text{pounds}}{\text{gallon}} = 10.67 \frac{\text{pounds}}{\text{gallon}}$$

**Step 2: Determine the "active ingredient" weight of the caustic soda based on the % purity of solution**

**a) Convert % purity of solution into a decimal:**

$$\frac{25\%}{100\%} = 0.25$$

**b) Multiply the weight of a gallon by the % purity of the product (as a decimal).**

$10.67 \frac{\text{pounds}}{\text{gallon}} \times 0.25 = 2.66$ pounds of caustic soda in a gallon of 25% caustic soda solution

This "active ingredient" weight provides the pounds of available caustic soda that is found in each gallon of 25% caustic soda solution. Within the 10.67 pounds of 25% caustic solution, there are **2.66 pounds of active ingredients.**

### ☑ Weight Calculation of "Active Chemicals" within % Solution in a Drum

**Practice Problem:** How many pounds of chemical are there in a 55 gallon drum of sodium hypochlorite that is 12½ percent pure with a specific gravity of 1.15?

? lbs of active ingredient within drum = Tank or Drum Volume X SG X 8.34 X % solution as a decimal.

? lbs of active ingredient within drum = 55 gal X 1.15 X 8.34 X 0.125 = **66** lbs of active ingredient (chlorine) within the 12.5% solution

## ☑ Total Weight Calculation of a single gallon of a % Solution

The measured specific gravity of the 11% strength Ferric Chloride delivered to your plant is 1.38. Find how much each gallon weighs.

Weight, lbs/gal = (Specific gravity of substance) x 8.34 (weight of water)

$$? \frac{\text{lbs}}{\text{gal}} \text{ of ferric chloride} = 1.38 \times 8.34 \frac{\text{lbs}}{\text{gal}} = 11.5 \frac{\text{lbs}}{\text{gal}}$$

## ☑ Drum Weight Calculation of a % Solution

How much does a 55 gallon drum of zinc orthophosphate weigh if the MSDS says the specific gravity of zinc orthophosphate is 1.46?

Drum Weight, lbs = (gallons of drum or tank) x (SG) x (8.34 lbs/gal)

? Drum weight, lbs = 55 x 1.46 x 8.34 = 671 lbs

Specific gravity is used in two ways:

- To calculate the **total weight** of a % solution (either as a single gallon or a drum volume). Total Weight = Drum Vol X SG X 8.34
- To calculate the **"active ingredient" weight** of a single gallon or a drum. Active Ingredient Weight within Drum = Drum Volume X SG X 8.34 X % solution as a decimal. (i.e., Total Weight X % solution as a decimal)

**NOTE:** Both ways start with solving for the **total weight** (Drum Vol X SG X 8.34). When solving for "active ingredient" weight, you have to then multiply by % solution as a decimal.

**Practice Problem:** A water treatment plant uses liquid alum for coagulation. At a plant flow rate of 2.0 MGD, an alum dosage of 12.5 mg/l is required. The alum has an “active ingredient” weight of 5.48 lb/gallon. Compute the required alum feed rate in **gallons/day.**

**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 = (2)(12.5)(8.34) = **208.5** pounds of liquid alum.

**Step 2:** Use “active ingredient” weight with unit cancellation steps to convert lbs/day to **gal/day**

Active Ingredient Weight of liquid alum

Step 1 Feed Rate of 100% pure alum

$$\frac{?\text{gal}}{\text{day}} = \frac{1\ \text{gallon}}{5.48\ \text{lbs}} \times \frac{\mathbf{208.5}\ \text{lbs}}{\text{day}} = \frac{\mathbf{38}\ \text{gal}}{\text{day}}$$

**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 to derive the “active ingredient” weight.**

## ✔ Practice – Theoretical Pump Output

An operator wants to estimate the approximate speed and stroke settings on a diaphragm pump that is rated to deliver a maximum pump output of 24 gallons per day. The system needs to deliver approximately 15 gallons per day of sodium hypochlorite. Where would the speed and stroke need to be set?

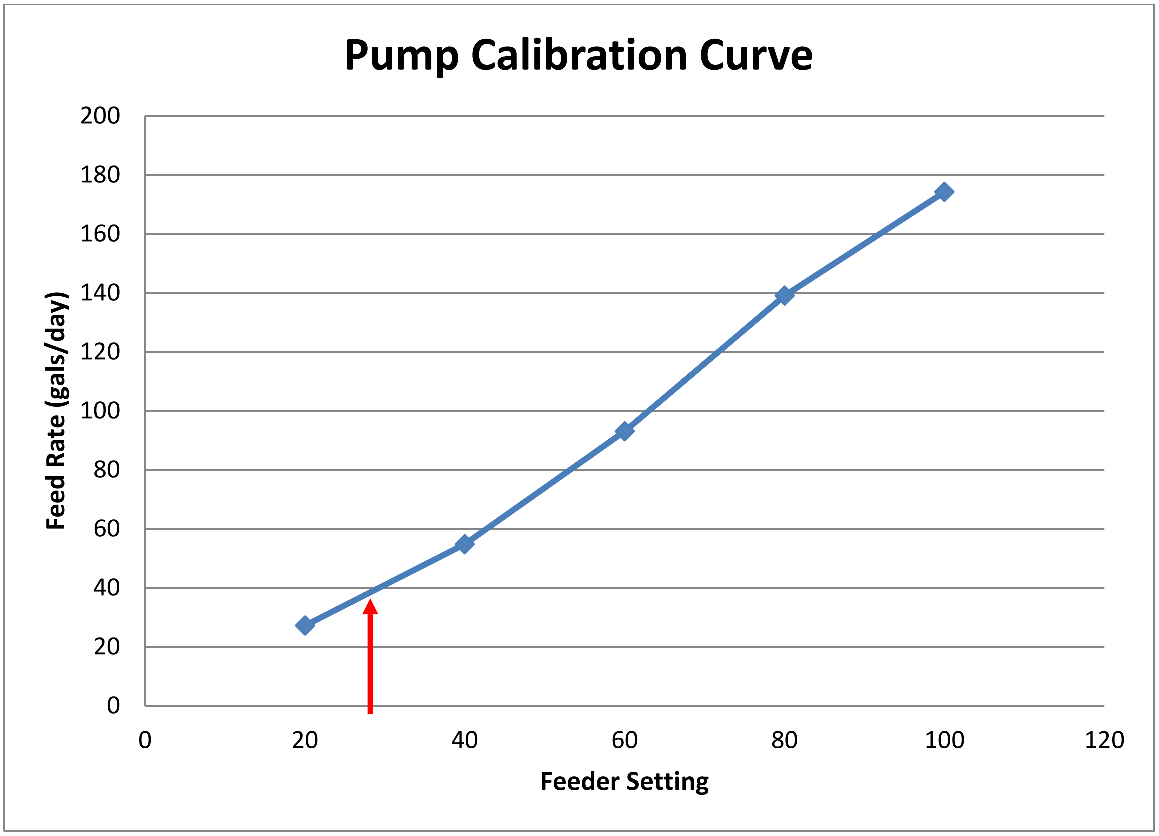
This is a guessing game of sorts; however, go again with the concept of a higher speed setting and a stroke setting between 20% and 80%.

**Pump Output = Maximum Pump Output x % Speed x % Stroke**

$$= \frac{24\ \text{gal}}{\text{day}} \times 0.90 \times 0.70$$

$$= \mathbf{\frac{15\ gal}{Day}}$$

**So the speed <u>could</u> be set at 90% and the stroke could be set at 70%**




So, the pump calibration curve graph shows the **Chemical Feed Rate** vs. the **Pump Setting**.

**Question:** Using this pump calibration curve, approximately what pump setting is required for a plant that has a liquid feed rate of 40 gal/day?

**Answer:** (between 20 and 40, less than 30)

## Example – Liquid Feed Calculations

Using Figure 3.9, if the plant ran for 8 hours, determine how many mL the pump would deliver at a pump setting of 20%. How many gallons would you expect to use?

| 60% Stroke Pump Calibration Table | | | | |
|---|---|---|---|---|
| Pump Speed Setting | Alum Pumped (mL) | Time (sec) | Feed Rate (mL/min) | Feed Rate (gal/day) |
| 0 | 0.0 | 30 | 0.00 | 0.000 |
| 20 | 65.6 | 55 | 71.56 | 27.2 |
| 40 | 141.9 | 59 | 144.31 | 54.8 |
| 60 | 249.1 | 61 | 245.02 | 93.1 |
| 80 | 195.2 | 32 | 366.00 | 139.1 |
| 100 | 267.4 | 35 | 458.40 | 174.2 |

Figure 3.9 Liquid Feeder Pump Calibration Table

Pump Setting 20: $$\text{Total Volume (ml)} = 71.56\ \frac{\text{mL}}{\text{min}} \times 60\ \frac{\text{mins}}{\text{1 hour}} \times 8\ \text{hrs} = 34{,}348.8\ \text{mL}$$

$$\text{Total Volume (gal)} = \frac{1\ \text{gal}}{3785\ \text{mL}} \times 34{,}348.8\ \text{mL} = 9\ \text{gallons}$$

**Unit 3 Exercise**

**Instructor Note:** Give students 10 or so minutes to complete the following questions, then review.

1. The suction assembly consist of:
   - A. **Suction Strainer** – Used to protect the internal components of a pump.
   - B. **Foot Valve** – Used to prevent the pump from losing prime.
2. A **Calibration Cylinder** is used for accurate determination of a pump's feed rate. This is typically located on the suction side of a pump.
3. Adjusting chemical feed pump dosage is controlled by
   - **A. The stroke (length of plunger)**
   - **B. The speed (number of repetitions)**
4. A **Volumetric Dry Feeder** has chemical stored in a silo above the unit and each time the system needs to make a new batch of solution, a feed mechanism delivers exactly the same volume of dry chemical to the dissolving tank.
5. A **Gravimetric Dry Feeder** is a belt type feeder that delivers a certain weight of material with each revolution of the conveyor belt.
6. **Jar Testing** is a laboratory procedure that simulates coagulation, flocculation, and precipitation results with differing chemical dosages.
7. **Active Strength** is a percentage of a chemical or substance in a mixture that can be used in a chemical reaction.
8. A pump calibration curve shows:
   - **A. Chemical Feed Rate**
   - **B. Pump Setting**
9. List three purposes of chlorine addition:
   - **A. Algae Control**
   - **B. Ammonia Removal**
   - **C. Disinfection**
10. A tank is 25 feet long, 15 feet wide and has 10 feet of water in it. Two wells pump into the tank; the first well pumps at a rate of 150 gpm and the second well pumps at a rate of 75 gpm. What is the detention time of the tank in hours?

A. First need to find the volume of the tank. V = l x w x d = 25 ft x 15 ft x 10 ft = 3750 $ft^3$

B. Convert $ft^3$ to gallons = gallons = 3750 $ft^3$ x 7.48 = 28,050 gallons

C. Solve for detention time = Vol/flow = 28,050 $ft^3$/225 gpm = 125 minutes

D. Convert minutes to hours = 125/60 = **2 hours**

11. A system is using "Aqua Mag" (specific gravity 1.34) to sequester iron and manganese in addition to corrosion control. What is the weight of 30 gallons of "Aqua Mag"?

    8.34 x 1.34 x 30 gallons = **335 lbs**

12. A treatment plant is feeding 25% caustic soda that has a specific gravity of 1.28. How many pounds of "active ingredient" are there in the 55 gallon drum?

    ? Wt = V X SG X 8.34 X % solution as a decimal

    = 55 X 1.28 X 8.34 X 0.25 = **146.7 lbs (rounded to 147)**

13. If a 24 gallon per day pump is set at 60 % speed and 80% stroke, how many gallons per day should the plant expect to feed?

    24 x 0.6 x 0.8 = **about 11.5 gallons per day**

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## Unit 4 Exercise

1. A general guideline to insure an adequate supply of chemicals at all times is to provide a minimum chemical storage the larger of either:

    **A. A 30 day supply at average use**
    **B. A 10 day supply at max use**

2. Spill containment areas should be designed to provide how much total containment?

    A. 80%
    B. 90%
    C. 100%
    **D. 110%**

3. Polymer requires addition of water, proper mixing, and aging prior to usage.

    **A. True**
    B. False

4. A self-contained breathing apparatus should be stored in the chlorine storage room.

    A. True
    **B. False**

5. Name the piece of equipment that provides the vacuum in a gas chemical feed system.

    A. Evaporator
    B. Emergency repair kit
    C. Self-contained breathing apparatus
    **D. Ejector**

# Appendix

## Extra Practice Math Problems

1. A sedimentation tank holds 60,000 gallons and the flow into the plant is 600 gpm. What is the detention time in minutes? **(ans =100 min)**
2. A tank is 20 feet by 35 feet by 10 feet. It receives a flow of 650 gpm. What is the detention time in minutes? **(ans = 81 min)**
3. Two wells flow into a 30,000 gallon tank. Well 1 flows at a rate of 475 gpm. Well 2 flows at a rate of 175 gpm. What is the detention time of the tank (in minutes)? **(ans = 46 min)**
4. A tank is 30 feet high, with a 53 foot diameter. It receives a flow of 900 gpm. What is the detention time in hours? **(ans = 9 hours)**
5. How many pounds of dry chemical must be added to a 80 gallon tank to produce a 10% solution? **(ans = 67 lbs)**
6. How many pounds of dry chemical must be added to a 100 gallon tank to produce a 2% solution? **(ans = 17 lbs)**
7. How many pounds of dry chemical must be added to a 35 gallon tank to produce a 3% solution? **(ans = 9 lbs)**
8. How many pounds of dry chemical must be added to a 50 gallon tank to produce a 5% solution? **(ans = 21 lbs)**
9. Determine the weight of a 55 gallon drum of zinc orthophosphate (specific gravity 1.46). **(ans = 670 lbs)**
10. The clearwell at a system is 25 feet long, 35 feet wide and contains 15 feet of water. It is to be disinfected at a dosage of 25 mg/l. How many pounds of 12.5% sodium hypochlorite do you need? **(ans = 164 lbs)**
11. How many pounds of dry chemical must be added to a 30 gallon tank to produce a 3% solution? **(ans=8 lbs)**
12. You receive a shipment of ferric chloride. They tell you it has a specific gravity of 1.39. How much does each gallon weigh (lbs)? **(ans = 11.6 lbs)**

**13.** A tank receives a flow of 350 gpm. The tank has a diameter of 30 feet and has 25 feet of water in it. What is the detention time (in minutes) in the tank? **(ans = 377 min)**

**14.** The flow to a clarifier is 2,400,000 gpd. If the lime dose required is determined to be 11.9 mg/L, how many lbs/day of lime will be required? **(ans = 238 lbs/day)**

**15.** How much does a 30 gallon drum of 60% fluorosilic acid weigh (lbs) if it has a specific gravity of 1.46? **(ans = 365 lbs)**

**16.** A plant is set at a flow of 3 MGD. The sedimentation tank is 30 feet long, 20 feet wide and has a water depth of 15 feet. What is the detention time (in minutes)? **(ans = 32 minutes)**

**17.** What is the volume ($ft^3$) of a tank that has a diameter of 48" and has 6 ft of water in it? **(ans = 75 $ft^3$)**

**18.** What would the volume (gallons) of a tank be if the tank had a diameter of 30 feet and was 30 feet high? **(ans = 158,538 gallons)**

**19.** DelPac has a specific gravity of 1.29. How much would you expect a 30 gallon drum to weight (in pounds)? **(ans = 323 lbs)**

**20.** An operator wants to estimate the approximate speed and stroke settings on a diaphragm pump that is rated to deliver a maximum output of 30 gallons per day. The system needs to deliver approximately 19 gallons per day of 50% caustic soda. Where would the speed and stroke need to be set? **(ans = 80% and 80%)**

**21.** An operator wants to estimate the approximate speed and stroke settings on a diaphragm pump that is rated to deliver a maximum output of 24 gallons per day. The system needs to deliver approximately 10 gallons per day of 12.5% sodium hypochlorite. Where would the speed and stroke need to be set? **(ans = 70% and 60%)**

**22.** A treatment plant uses liquid alum for coagulation. The plant is treating 875 gpm and an alum dosage of 10.5 mg/L is required. The alum has an "active ingredient" weight of 5.48 lb/gallon. Compute the required alum feed rate in gallons/day. **(ans = 20 gal/day)**

## Homework

1. Coagulation: The clumping together of very fine particles into larger particles (floc) caused by the use of chemicals (coagulant chemicals). The chemicals neutralize the electrical charges of the fine particles and cause destabilization of the particles. This clumping together makes it easier to separate the solids from the water by settling, skimming, draining or filtering.
2. Name three types of primary coagulants:
   a. Aluminum Sulfate (alum)
   b. Poly Aluminum Chloride (PAC)
   c. Ferric chloride
3. Name three chemicals which will raise pH and three chemicals which will lower pH:
   a. Raise
      i. Sodium Hydroxide (caustic)
      ii. Calcium Hydroxide (lime)
      iii. Soda Ash
   b. Lower
      i. Nitric Acid
      ii. Alum
      iii. Hydrochloric Acid

4. Alkalinity: the capacity of a water to neutralize acids. This capacity is caused by the water's content of bicarbonate, carbonate and hydroxide.
5. Alkalinity and pH may be increased by the addition of lime, caustic soda or soda ash. Sodium bicarbonate (Bicarbonate Soda) will only make water more alkaline.
6. Name the two general methods for controlling tastes and odors.
   a. Removal
   b. Oxidation/Destruction
7. Water may need softened to remove excess hardness caused by calcium and magnesium.

8. What factors should be considered when selecting a fluoridation chemical:
    a. The solubility of the chemical in water will determine how readily it dissolves in water and how well it remains in solution.
    b. Storage and feeding requirements must be considered in addition to operator health and safety.
    c. Proper personal protective equipment

9. Chlorine can be added to the water in the form of:
    a. chlorine gas
    b. hypochlorite (sodium or calcium)
    c. chlorine dioxide
10. SDS contain detailed assessment of chemical characteristics, hazards, and other information relative to health, safety, and the environment.
11. The SDS for Aluminum Sulfate states the:
    a. Specific gravity = 1.32
    b. pH = 2.1
12. An emergency response plan (ERP) must be developed to help a system protect public health, limit damage to the system and the surrounding area, and help a system return to normal as soon as possible.
13. Suction Assembly – Should be suspended just above the bottom of the tank so as not to pull in any solids that might have settled to the bottom of the tank.
14. A calibration cylinder consists of a graduated cylinder typically located on the suction side of the pump. It is used for accurate determination of the pump's feed rate.
15. The output of the pump is controlled by the length of the plunger and the number of repetitions. This is the:
    a. The stroke
    b. The speed

16. What chemicals can be fed using a dry feeder?
    a. Lime
    b. Fluoride
    c. Carbon

d. potassium permanganate

17. Name the two types of dry feeders?

a. Volumetric
b. Gravimetric

18. Jar Testing is a laboratory procedure that simulates coagulation, flocculation, and precipitation results with differing chemical dosages.

19. After a jar test, evaluate jar test results for:

a. Rate of floc formation
b. Type of floc
c. Floc settling rate
d. Clarity of settled water

20. Solute: The dry product that you are adding or the amount of dry product in a concentrated solution.

21. Feed Rate is the quantity or weight of chemical delivered from a feeder over a given period of time.

22. A tank holds 75,000 gallons. A pump is flowing at 75 gpm. What is the detention time in hours?

$$\text{Detention Time (time)} = \frac{\text{Volume}}{\text{Flow}} = \frac{75{,}000 \text{ gallons}}{75 \text{ gpm}} = 1{,}000 \text{ minutes}$$

$$\text{Hours} = 1{,}000 \text{ min} \times \frac{\text{hr}}{60 \text{ min}} = 16.6 \text{ hours (don't want to round up)}$$

23. A flocculation basin is 7 ft deep, 15 ft wide, and 30 ft long. If the flow through the basin is 1.35 MGD, what is the detention time in minutes?

Volume = 7 ft x 15 ft x 30 ft = 3,150 $ft^3$ x 7.48 = 23,562 gallons

$$\text{Detention Time (time)} = \frac{\text{Volume}}{\text{Flow}} = \frac{23{,}562 \text{ gallons}}{1{,}350{,}000 \text{ gdp}} = 0.017 \text{ day}$$

$$\text{Minutes} = 0.017 \text{ day} \times \frac{1440 \text{ min}}{\text{day}} = 24 \text{ minutes}$$

24. A basin, 4 ft by 5 ft, is to be filled to the 2.5 feet level. If the flow to the tank is 5 gpm, how long (in hours) will it take to fill the tank?

Volume = 4ft x 5 ft x 2.5 ft = 50 $ft^3$ x 7.48 = 374 gallons

$$\text{Detention Time (time)} = \frac{\text{Volume}}{\text{Flow}} = \frac{374 \text{ gallons}}{5 \text{ gpm}} = 75 \text{ minutes}$$

$$\text{Hours} = 75 \text{ min} \times \frac{\text{hr}}{60 \text{ min}} = 1.2 \text{ hours (don't want to round up)}$$

25. A tank has a diameter of 60 feet with an overflow depth at 44 feet. The current water level is 16 feet. Water is flowing into the tank at a rate of 250 gallons per minute. At this rate, how many days will it take to fill the tank to the overflow?

Volume = 0.785 x $(60\ ft)^2$ x 28 ft = 79,128 $ft^3$ x 7.48 = 591,877 gallons

Detention Time (time) = $\frac{\text{Volume}}{\text{Flow}}$ = $\frac{\text{591,877 gallons}}{\text{250 gpm}}$ = 2,368 minutes

Days = 2,368 minutes x $\frac{\text{days}}{\text{1440 minutes}}$ = 1.6 days

26. How many pounds of dry chemical must be added to a 50 gallon tank to produce a 2% solution?

Pounds = $\frac{\text{8.34 pounds}}{\text{gallon}}$ x 50 gallons x 0.02 = 8.34 pounds

27. How many pounds of dry chemical must be added to a 100 gallon tank to produce a 5% solution?

Pounds = $\frac{\text{8.34 pounds}}{\text{gallon}}$ x 100 gallons x 0.05 = 42 pounds

28. How many pounds of dry chemical must be added to a 75 gallon tank to produce a 8% solution?

Pounds = $\frac{\text{8.34 pounds}}{\text{gallon}}$ x 75 gallons x 0.08 = 50 pounds

29. How much does each gallon of zinc orthophosphate weigh (pounds) if it has a specific gravity of 1.46?

Pounds of zinc orthophosphate (in one gallon) = 1.46 x 8.34 = 12 pounds/gal

30. How much does a 55 gallon drum of 25% caustic soda weigh (pounds) if the specific gravity is 1.28?

Pounds of 25% caustic (in one gallon) = 1.28 x 8.34 = 10.7 lbs/gal
So for 55 gallons, 10.7 x 55 = 587 pounds

31. 60% hydrofluosilicic acid has a specific gravity of 1.46. How much (in pounds) does a 55 gallon drum weigh?

Pounds of 60% hydrofluosilicic acid (in one gallon) = 1.46 x 8.34 = 12.18 lbs/gal
So for 55 gallons, 12.18 x 55 = 670 pounds

32. An operator wants to estimate the approximate speed and stroke settings on a diaphragm pump that is rated to deliver a maximum output of 24 gallons per day. The system needs to deliver approximately 10 gallons per day of sodium hypochlorite. Where would the speed and stroke need to be set?

This is a guessing game of sorts; however, go again with the concept of a higher speed setting and a stroke setting between 20% and 80%.

Pump Output = Maximum Pump Output x % Speed x % Stroke

$$= \frac{24\ gal}{day} \times 0.70 \times 0.60$$

$$= \frac{10\ gal}{Day}$$

The speed could be set at 70% while the stroke could be set at 60%

33. An operator wants to estimate the approximate speed and stroke settings on a diaphragm pump that is rated to deliver a maximum output of 30 gallons per day. The system needs to deliver approximately 19 gallons per day of 50% caustic soda. Where would the speed and stroke need to be set?

$$\text{Pump Output} = \text{Maximum Pump Output} \times \%\ \text{Speed} \times \%\ \text{Stroke}$$

$$= \frac{30\ \text{gal}}{\text{day}} \times 0.80 \times 0.80$$

$$= \frac{19\ \text{gal}}{\text{Day}}$$

The speed could be set at 80% while the stroke could be set at 80%