Module 20:
Corrosion Control and Sequestering
Answer Key

(edited June 2014)

Exercise for Unit 1 – Background and Properties

1. Under the LCR, insert the population sizes for the following types of systems:

System Size	Population Served
Small	**3,300 and fewer**
Medium	**3,301 to 50,000**
Large	**50,001 and greater**

2. Based on the following lead tap sample results, what is the 90th percentile value of the following samples? **0.018 mg/L**
Is this system exceeding the action level? **YES**

Sample site	Lead Level (mg/L)
1	0.020
2	0.018
3	0.016
4	0.014
5	0.011
6	0.010
7	0.009
8	0.008
9	0.007
10	0.006

3. When a small or medium system exceeds an AL, name the first step in the corrosion control treatment activity milestones? Submit a CCT **feasibility study** within 18 months.

4. Which of the following parameters are considered water quality parameters?

   Circle all that apply.

   a. Temperature

b. Conductivity

c. pH

d. alkalinity

e. odor

Answer: a, b, c, and d.

5. Systems serving 50,000 or less people (i.e. small or medium systems) must collect WQP samples during monitoring periods in which either AL is exceeded.

   a. True___**X**___ b. False______

6. The sample volume size for a lead and copper tap sample is:

   a. 500 ml b. **1 liter**

7. An operator must measure pH within **15** minutes of sample collection.

8. What methodology is **NOT** an EPA-approved method?

   a. Titrimetric

   b. Electrometric

   c. Colorimetric

   d. Color Wheel

Exercise for Unit 2 – Corrosion Principles and Theory

1. When placed in water, **acids**/bases produce hydrogen ions; acids/**bases** produce hydroxide ions.

2. A **salt** is the product of combining an acid and a base.

3. A finished water pH value of 5.0 indicates:

    a. Water is basic
    b. Water is acidic
    c. Water may corrode pipes and fittings
    d. Both a and c
    e. Both b and c

4. What objectives can be met with corrosion control treatment?

    a. Minimize amount of lead and/or copper dissolving into tap water.
    b. Maximize the service life of plumbing materials.
    c. Improve the hydraulic characteristics of water distribution systems.
    d. All of the above.

5. Controlling lead/copper is achieved by forming a protective layer on the pipe wall that eliminates the corrosion cell.

    a) **True** b) False

6. What does a Langelier Saturation Index of 1.1 indicate?

    a. Scaling potential
    b. Dissolving potential

7. If an operator adjusts the pH of the finished water above the saturation point for calcium carbonate, this will create a protective coating on the pipe wall.

    a) **True** b) False

8. Determine how the addition of the following chemicals to water will affect pH and complete the table.

If I add:		The pH will be ___________ (raised/lowered)
potassium hydroxide	KOH	**raised**
nitric acid	HNO_3	**lowered**
lime	$Ca(OH)_2$	**raised**
sulfuric acid	H_2SO_4	**lowered**
caustic soda	NaOH	**raised**
soda ash	Na_2CO_3	**raised**
hydrochloric acid	HCl	**lowered**

Common Chemical Names

Table 3.1 - Common pH/Alkalinity Adjustment Chemicals

Chemical Name	Chemical Formula	Common Name
Sodium Hydroxide	$NaOH$	Caustic Soda
Calcium Hydroxide	$Ca(OH)_2$	Lime
Sodium Bicarbonate	$NaHCO_3$	Baking Soda
Sodium Carbonate	Na_2CO_3	Soda Ash

Q. *Do these chemicals act like acids or bases? (**bases**)*

Q. *Are caustic soda and lime stronger or weaker bases than soda ash or sodium bicarbonate? (**stronger**)*

Q. *Why? (**Hydroxides produce a greater pH change for the same dosage than carbonates and bicarbonates**.)*

Exercise for Unit 3 – Corrosion Control Chemicals

1. List the common names for the following pH/alkalinity adjustment chemicals:

Chemical Name	Common Name
Calcium hydroxide	**Lime**
Sodium carbonate	**Soda Ash**
Sodium hydroxide	**Caustic soda**

2. When using caustic soda, it is necessary to have at least 20 mg/L of alkalinity to maintain a stable pH.

   a) **True** b) False

3. It is not necessary to minimize the length of line for a lime feeder.

   a) True b) **False**

4. Which type of inhibitor is used to control lead?

   a) Polyphosphate
   b) Silicates
   c) Orthophosphate

5. When the pH is raised before disinfection, the inactivation effectiveness of free chlorine is increased.

   a) True b) **False**

6. When using polyphosphates to **sequester** iron and manganese, why should the chemical feed point be located **before** the disinfection process?

To avoid oxidizing the iron and manganese with the chlorine which would create iron and manganese precipitates to be pumped out into the distribution system.

Practice Problem: Mixing a Percent Solution

How many pounds of caustic soda are required to be mixed with 50 gallons of water to produce a 12% solution?

$?\text{lbs} = 8.34 \frac{\text{lbs}}{\text{gal}} \times \text{Volume (gal)} \times$ % Strength Solution (either as a decimal or a fraction)

$?\text{lbs} = 8.34 \frac{\text{lbs}}{\text{gal}} \times$ **50** gal $\times \frac{12}{100}$ (or **0.12** as a decimal)

?lbs = 8.34 X **50** (gal) X **0.12** (% strength solution as a decimal)

?lbs = **50.04** lbs

Dry Feed Practice Problem

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

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

$$?MG = \frac{1\ MG}{1{,}000{,}000\ \cancel{gal}} \times 200\ \frac{\cancel{gal}}{\cancel{min}} \times 1440\ \frac{\cancel{mins}}{day}\ gal = \mathbf{0.288}\ MGD$$

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 = **(0.288)(17)(8.34)** = **40.8** pounds of lime is required.

Liquid Feed Rate Practice Problem: A water plant uses 25% caustic soda to raise the pH of the water. The target dose is 20 mg/L. They treat 600 gpm. How many **pounds** of caustic soda will need to be fed?

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

$$?MG = \frac{1\ MG}{1{,}000{,}000\ \not{gal}} \times (600)\ \frac{\not{gal}}{\not{min}} \times 1440\ \frac{\not{mins}}{day}\ gal = \mathbf{0.864}\ MGD$$

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 = (**0.864**)(20)(8.34) = **144** pounds of "pure" caustic soda.

Step 3: Calculate # of pounds of 25% solution needed to achieve Step 2 feed rate.

a) Convert % purity of solution into a decimal:

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

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

$$\frac{144\ pounds}{0.25\ (\%\ purity\ as\ a\ decimal)} = \mathbf{576\ pounds}\ of\ 25\%\ caustic\ soda.$$

TIP: Answer will always be more pounds than Step 2 result because solution is not 100% pure.

Practice Problem: Calculating the Active Ingredient Weight of a % Solution Chemical

EXAMPLE: How many pounds of caustic soda are there in a gallon of caustic soda that is 50% pure that has a specific gravity of 1.53?

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)

$$1.53 \times 8.34 \frac{\text{pounds}}{\text{gallon}} = \mathbf{12.76} \frac{\text{pounds}}{\text{gallon}}$$

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:

$$\frac{50\%}{100\%} = \mathbf{0.50}$$

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

$$12.76 \frac{\text{pounds}}{\text{gallon}} \times 0.5 = \mathbf{6.38}$$ pounds of caustic soda in a gallon of 50% caustic soda solution

This "active ingredient" weight provides the pounds of active strength ingredients that are found in each gallon of 50% caustic soda solution. Within the 12.76 pounds of 50% caustic solution, there are 6.38 pounds of active ingredients.

Liquid Feed Rate Practice Problem: A water plant uses 50% caustic soda to raise the pH of the water. The target dose is 30 mg/L. They treat 500 gpm. Specific gravity of 50% caustic soda is 1.53
How many **gallons** of caustic soda will need to be fed?

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)

$$1.53 \times 8.34 \frac{\text{pounds}}{\text{gallon}} = \mathbf{12.76} \frac{\text{pounds}}{\text{gallon}}$$

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:

$$\frac{50\%}{100\%} = \mathbf{0.5}$$

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

$12.76 \frac{\text{pounds}}{\text{gallon}} \times 0.5 = \mathbf{6.38}$ pounds of "active" caustic soda in a gallon of 50% caustic soda solution

Step 3: Convert flow (in gallons) into MGD so that the feed rate (lbs) formula can be used.

$$?\text{MGD} = \frac{1\ \text{MGD}}{1{,}000{,}000\ \text{gal}} \times (500) \frac{\text{gal}}{\text{min}} \times 1440 \frac{\text{mins}}{\text{day}} = \mathbf{0.72}\ \text{MGD}$$

Step 4: Solve for pounds per day (feed rate) for 100% pure chemical (no impurities).

Using the formula lbs/day = flow x dose x 8.34 = (**0.72**)(30)(8.34) = **180** pounds of "pure" caustic soda.

Step 5: Use unit cancellation to convert lbs/day to gals/day

"Active Ingredient" Weight of 50% caustic soda solution

Feed Rate of "100% pure" caustic soda

$$\frac{?\text{gal}}{\text{day}} = \frac{1\ \text{gallon}}{\mathbf{6.38\ lbs}} \times \frac{\mathbf{180}\ \text{lbs}}{\text{day}} = \frac{\mathbf{28.2\ gals}}{\mathbf{day}}$$ of 50% caustic soda

Exercise for Unit 4 – Chemical Feed Components and Pump Calibration

1. Liquid chemical feed components consist of:
   a. Chemical Storage
   b. Calibration cylinder
   c. Metering Pump
   d. Pulsation Damper
   e. All of the above

2. Secondary spill containment areas should be provided and include leak detection equipment to provide an alarm in the event of a chemical spill or leak.

   a) **True** b) False

3. The **foot valve** is used to prevent the pump from losing prime.

4. A clogged suction assembly can be cleaned with a weak acid solution (i.e., vinegar or 1:1HCL).

   a) **True** b) False

5. Volumetric/**Gravimetric** dry feeders are extremely accurate.

6. Chemical feed calculations involve 4 considerations:

1. Dosage
2. Plant Flow
3. Chemical Product Strength
4. **Product Feed Rate**

7. Why should the discharge point of the injector assembly should be located in the middle of the flow of the pipe?

   To provide proper mixing.

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