DW Module 22
Inorganic Removal Basics
Answer Key

Appendix D: Inorganic Removal Pre-Test

1. Solve the following equation: $\frac{385 + (21/7) - (5 \times 13 \times 4)}{17 + 11 - (6 \times 4)} =$

   a. 9
   b. 7
   c. 31
   d. 32

Answer: d. 32

2. The following is NOT an inorganic contaminant:
   a. Arsenic
   b. Benzene
   c. Copper
   d. Lead

Answer: b. benzene (this is a volatile organic contaminant; aka a VOC)

3. Potassium permanganate:
   a. Will color water green if too much is added
   b. Is a strong oxidizer
   c. Is the typical name given to sodium carbonate

Answer: b. Is a strong oxidizer

4. Adding a base to water __________ the pH; adding an acid to water ___________ the pH
   a. lowers; drops
   b. raises; spikes
   c. lowers; raises
   d. raises; lowers

Answer: d. raises; lowers

5. Solve for X in the following equation: $2.5 = \frac{1,000}{X}$

   a. X = 0.0025
   b. X = 2,500
   c. X = 400
   d. X = 1,000

Answer: c. X = 400

6. Excessive iron in the water can cause:
   a. The water to have a rust or orange color
   b. The water to have a sweet taste
   c. The water to stain plumbing fixtures black

Answer: a. The water to have a rust or orange color

7. The use of coagulant chemicals promotes:
   a. medium particles to stay the same size
   b. small particles to clump together into larger particles
   c. larger particles to break down into smaller particles

Answer: b. small particles to clump together into larger particles

8. A cylindrical inorganic filter has a diameter of 20 feet. What is the filter media surface area?
   (Hint: The formula for area of a circle = (0.785)(Diameter^2))
   a. 7.85 ft^2
   b. 17 ft^2
   c. 314 ft^2
   d. 177 ft^2

Answer = c. 314 ft^2

9. The presence of which mineral in drinking water can make it "hard water."
   a. potassium
   b. sodium
   c. calcium

Answer = c. calcium

10. 54 inches is how many feet? (Hint: 1 foot = 12 inches)

Answer = 4.5 feet

Unit 1

Unit 1, Exercise #1 – Inorganic Contaminant Basics

1. __________ contaminants are regulated in drinking water because of the potential to cause a health effect.
   a. Primary
   b. Secondary

Answer: a. Primary

2. ___________ contaminants are mainly considered to have aesthetic (e.g. taste, odor) or cosmetic (e.g. tooth staining) effects.
   a. Primary
   b. Secondary

Answer: b. Secondary

3. The MCL is the _____________ permissible level of a contaminant in water which is delivered to a user of a public water system. (*Choose the correct answer to fill in the blank.*)
   a. minimum
   b. maximum

Answer: b. maximum

4. The main concern about **primary** inorganic contaminants in drinking water is that they can cause aesthetic effects such as taste and odor problems.
   a. True
   b. False

Answer: b. False (The main concern is that they have potential health effects associated with them)

5. The source of some inorganics is the erosion of natural deposits.
   a. True
   b. False

Answer: a. True

Unit 1 Exercise #2 – Inorganic Contaminant Basics

1. In Pennsylvania, who is responsible for ensuring that samples for inorganic contaminants are collected, analyzed, and that the results are reported?

a. The water supplier

b. Pennsylvania DEP

c. PA Dept. of Health

d. River Basin Commission

Answer: a. The water supplier

2. Excess iron in the drinking water can potentially cause which of the following aesthetic issues: *(Choose all that apply)*

a. Reddish or orange staining of laundry

b. Cancer

c. Metallic taste

d. Sediment

Answer: a, c, and d; b is incorrect because iron is not known to cause this effect, plus cancer is a health issue instead of an aesthetic issue.

3. Typically, how often are community water systems in Pennsylvania required to monitor for secondary contaminants? (Choose the best answer)

a. Monthly

b. During sampling of a new source

c. Annually

d. Every 3 years

Answer: b. During sampling of a new source

4. Excess manganese in the drinking water can potentially cause which of the following aesthetic issues: (Choose all that apply)

a. Black to brown colored water
b. Metallic taste
c. Black staining of plumbing fixtures
d. Reddish-orange staining of laundry

Answer: a, b, and c; excess manganese in drinking water can potentially cause all of these aesthetic issues.

5. Excess iron in drinking water can also have "technical effects" on water treatment and plumbing issues. It can also cause damage to water equipment and reduce effectiveness of water treatment for other contaminants.

a. True
b. False

Answer: a. True

Unit 2

Unit 2, Practice #1: Basic Math Calculations:

1. (85 x 17) + (22 x 12) =

Answer: 1,445 + 264 = 1,709

2. $\frac{(145 \times 9 \times 2) - (14 \times 9 \times 2) + 162}{(7 \times 5) - (10/2) + 150} =$

Answer: $\frac{2,610 - 252 + 162}{35 - 5 + 150} = \frac{2,520}{180} = 14$

Unit 2, Practice #2 – Solving for X:

Directions: Solve for x in the following problems.

1. $\frac{X}{200} = 2.4$ X = ______

Answer: Multiply both sides by 200, the 200's on the one side cancel out to leave X as shown below.

$(\cancel{200})\,\frac{X}{\cancel{200}} = 2.4\ (200)$

X = 480

2. $10 = \frac{3000}{X}$ X = ______

Answer: Multiply both sides by X to move it into the numerator (the x's cancel out). Then divide by 10 on both sides of the equation (the 10's then cancel out) as shown below.

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

X = 300

Unit 2, Practice #3 – Filter Surface Area:

1. A greensand filter has a diameter of 20 feet. What is the filter surface area?

   a. 40 ft^2

   b. 31.4 ft^2

   c. 314 ft^2

   d. 400 ft^2

   Answer: c. 314 ft^2 – Below is shown how to solve this problem

   What we know:
   - This problem gives us a radius, so we know we are dealing with a circular shape.
   - We need to find the surface area, which is in ft^2.
   - The formula that helps us find the area of a circle is as follows:

     Area of a circle = (0.785)($Diameter^2$)

     We plug in the number we have:

Area of a circle = (0.785) [(20 feet)(20 feet)] $\longrightarrow$ (0.785) (400 ft^2) $\longrightarrow$ = **314 ft^2**

2. A mixed media filter has a length of 50 feet and a width of 456 inches. What is the surface area of the filter?

a. 80 ft^2

b. 410 ft^2

c. 1,900 ft^2

d. 22,800 ft^2

Answer: c. 1,900 ft^2 – Below is shown how to solve this problem

What we know:

- This problem gives us a length and a width, so we know we are dealing with a rectangular shape.
- We need to find the surface area, which for this filter is in ft^2.
- The formula that helps us find the area of a rectangle is as follows:

Area of a rectangle = (length)(width)

- One of the items is in inches, so we need to convert that to feet before proceeding further.

Step 1: Convert 456 inches into X feet, using the conversion of 12 inches = 1 foot. Let's review conversion principals:

Unknown: X feet =

$$\text{X feet} = \frac{\text{1 foot}}{\text{12 inches}}$$ *Conversion*

$$\text{X feet} = \frac{\text{1 foot}}{\text{12 }\cancel{\text{inches}}} \times 456\ \cancel{\text{inches}}$$ *Known*

X feet = 0.0833 feet x 456 = **38 feet**

Step 2: The formula that helps us find the volume of a rectangle is as follows:

Area of a rectangle = (length)(width)

We plug in the numbers we have:

Area of a rectangle = (50 feet) (38 feet) $\longrightarrow$ **1,900 ft^2**

Unit 2, Practice #4 – Filter Surface Area and Volume:

1. A greensand filter has a length of 50 feet, a width of 30 feet and a height of 300 inches. What is the volume of the filter?

   a. 2,355 ft^3

   b. 18,000 ft^3

   c. 37,500 ft^3

   d. 450,000 ft^3

Answer: c. 37,500 ft^3 – Below is shown how to solve this problem

What we know:

- This problem asks for the answer to be in ft^3 so we know we need to determine volume.
- Also, the three measurement items indicate we are dealing with a rectangle.
- One of the items is in inches, so we need to convert that to feet before proceeding further.

Step 1: Convert 300 inches into X feet, using the conversion of 12 inches = 1 foot. Let's review conversion principals:

Unknown: X feet =

$$\text{X feet} = \frac{\text{1 foot}}{\text{12 inches}}$$

Conversion

$$\text{X feet} = \frac{\text{1 foot}}{\text{12 } \cancel{\text{inches}}} \times 300 \cancel{\text{ inches}}$$

Known

X feet = 0.0833 feet x 300 = **25 feet**

Step 2: The formula that helps us find the volume of a rectangle is as follows:

Volume of a rectangle = (length)(width)(height)

We plug in the numbers we have:

Volume of a rectangle = (50 feet) (30 feet) (25 feet) $\longrightarrow$ = **37,500 ft^3**

2. A greensand filter has a length of 40 feet and a width of 30 feet. What is the filter surface area?

   a. 70 ft^2
   b. 700 ft^2
   c. 942 ft^2
   d. 1,200 ft^2

   Answer: d. 1,200 ft^2 – Below is shown how to solve this problem

What we know:

- This problem gives us a length and a width, so we know we are dealing with a rectangular shape.
- We need to find the surface area, which for this filter is in ft^2.
- The formula that helps us find the area of a rectangle is as follows:

Area of a rectangle = (length)(width)

Area of a rectangle = (40 feet) (30 feet) $\longrightarrow$ 1,200 ft^2

3. A manganese greensand filter has a diameter of 10 feet and a height of 35 feet. What is the volume of the filter?

   a. 2,748 ft^3
   b. 18,000 ft^3
   c. 37,500 ft^3
   d. 450,000 ft^3

Answer: a. 2,748 ft^3 – Below is shown how to solve this problem

What we know:

- This problem asks for the answer to be in ft^3 so we know we need to determine volume.
- Also, the two measurement items – one being a diameter - indicate we are dealing with a cylinder.

Volume of Cylinder (ft^3) = (0.785) (Diameter^2)(Height)

Volume of Cylinder (ft^3) = (0.785) [(10 feet)(10 feet)] (35 feet) $\longrightarrow$ (0.785)(100 sq. ft.) (35 feet)

= (0.785)(3,500 ft^3) $\longrightarrow$ 2,748 ft^3

Unit 3

Unit 3, Exercise #1 – Inorganic Removal Chemistry

Match the lettered item with the correct numbered definition:

a. sequestration b. precipitate c. saturation point d. ion exchange

1. ___b.___ When solid particles fall out of a solution, the solid particles are given this term
2. ___c.___ Precipitation of a chemical occurs when it is added to a solution past this maximum amount
3. ___d.___ Inorganic pollutants are removed from water by attaching to a polymeric resin that exchanges pollutant ions in exchange for non-pollutant ions.
4. ___a.___ A metal ion is bound to form a stable compound so it is no longer available for reactions.

Unit 3, Exercise #2 – Inorganic Removal Additives

Choose the letter of the correct item with the action the chemical commonly takes on certain inorganics:

1. The common reaction polyphosphates have on iron and manganese to keep them in solution.

a. Sequesters

b. Oxidizes

Answer: a. sequesters

2. The common reaction potassium permanganate has on iron and manganese so they precipitate out.

a. Sequesters

b. Oxidizes

Answer: b. oxidizes

3. Even though chlorine is commonly used in drinking water disinfection, it reacts this way to remove iron, manganese, and arsenic.

a. Sequesters

b. Oxidizes

Answer: b. oxidizes

4. Chlorine is a better oxidizer of manganese than potassium permanganate.

a. True

b. False

Answer: b. False

5. The formation of corrosive products can be a limitation when using chlorine as an oxidant.

a. True

b. False

Answer: a. True

6. Circle all the oxidizers (choose all that apply)

a. Ozone

b. Chlorine

c. Sodium hexametaphosphate

d. Potassium permanganate

e. The treatment process of aeration

Answer: a., b., d, and e. (Sodium hexametaphosphate was not selected because it is a sequestering agent)

Unit 3, Exercise #3 – Effect of pH on Iron & Manganese Removal:

1. If Hydrochloric Acid – HCl - is added to water, will it raise or lower the pH?

a. Raise the pH

b. Lower the pH

Answer: b. Hydrochloric Acid is an acid, so it will lower the pH

2. If Calcium Hydroxide – $Ca(OH)_2$ – (known as slaked lime) is added to water, will it raise or lower the pH?

a. Raise the pH

b. Lower the pH

Answer: a. Calcium Hydroxide is a base, which will raise the pH

3. Another term for a basic solution with a pH greater than 7 is to say the solution is ______

a. alkaline

b. acidic

c. neutral

Answer: a. alkaline

4. If you want to remove iron and manganese by aeration, which is the **best** pH for the water to be?

a. A pH of 10 - 12

b. A pH of 8 - 9

c. A pH of 6 - 7

Answer: b. A pH of 8 – 9

5. If you want to remove iron and manganese using potassium permanganate, which is the **best** pH for the water to be?

a. A pH of 10 - 12

b. A pH of 6 - 8

c. A pH of 3 - 5

Answer: b. A pH of 6 - 8

Unit 3, Exercise #4 – Effect of Water Temperature on Iron & Manganese Removal

Choose the correct answer:

Chemical	Significant effect if water is cold?
Iron removal using aeration	a. Yes (correct answer) b. No
Manganese removal using aeration	a. Yes (correct answer) b. No
Iron removal – in water below 35°F- using potassium permanganate	a. Yes b. No (correct answer)
Manganese removal – in water below 35°F- using potassium permanganate	a. Yes (correct answer) b. No
Iron removal using chlorine	a. Yes (correct answer) b. No
Manganese removal using chlorine	a. Yes (correct answer) b. No

Answer: Cold water has a significant effect on all of the below <u>except </u>when removing iron in water below 35^{o}F- using potassium permanganate

- Iron removal using aeration – a. Yes
- Manganese removal using aeration – a. Yes
- <u>Iron removal – in water below 35^{o}F- using potassium permanganate – b. No</u>
- Manganese removal – in water below 35^{o}F- using potassium permanganate – a. Yes
- Iron removal using chlorine – a. Yes
- Manganese removal using chlorine – a. Yes

Unit 4

Unit 4 Exercise – Inorganic Treatment Methods

1. The presence of which mineral in drinking water can make it “hard water.”

    a. potassium

    b. sodium

    c. calcium

Answer c. calcium

2. When iron has combined with natural organics, it can be easier to remove from drinking water.

    a. True

    b. False

Answer b. False

3. Sodium hexametaphosphate is used to oxidize iron and manganese.

    a. True

    b. False

Answer b. False (the polyphosphates are used as sequestering agents to keep contaminants in solution, not as oxidizers, which help contaminants precipitate out.)

4. A common treatment method to soften water is by ion exchange

   a. True

   b. False

Answer a. True

5. Potassium permanganate sequesters manganese to aid in removal through filtration.

   a. True

   b. False

Answer b. False (it oxidizes manganese)

6. During water softening the "hard water" _________ and __________ ions stick to the resins and replace the ______ ions, which are then released into the water.

   a. sodium and calcium, magnesium

   b. calcium and magnesium, sodium

   c. potassium and magnesium, calcium

Answer b. calcium and magnesium, sodium

7. The feeding of a sequestering agent must occur ________ the addition of any chemical that has oxidant properties. For example, where would sodium metaphosphate sequestration treatment occur in relationship to chlorine treatment? *(Choose the best answer to fill in the blanks.)*

   a. before

   b. after

Answer: a. before

8. Aeration can be a useful treatment for removing low levels of hydrogen sulfide from drinking water; it is also a useful treatment for removing radon from drinking water. Aeration can also be used to ____________ iron by causing it to precipitate out prior to filtration.

   a. sequester

   b. oxidize

Answer: b. oxidize

Unit 5

Unit 5 Practice #1:

1. You have a filter that is 45 feet long by 30 feet wide that treats 60 gpm. What is the filter loading rate in gpm/ ft^2?

a. 81,000 gpm/ ft^2
b. 22.5 gpm/ ft^2
c. 0.23 gpm/ ft^2
d. 0.044 gpm/ ft^2

Answer:

$$\text{Filter Loading Rate (gpm/ ft}^2\text{)} = \frac{\text{Flow Rate (gpm)}}{\text{Surface Area (ft}^2\text{)}}$$

Step 1: Surface Area of a Rectangular Filter (ft^2) = (Length)(Width)= (45 feet long) (30 feet wide) =**1,350 ft^2**

Step 2: $\text{Filter Loading Rate (gpm/ ft}^2\text{)} = \frac{\text{Flow Rate (gpm)}}{\text{Surface Area (ft}^2\text{)}} = \frac{60 \text{ gpm}}{1{,}350 \text{ ft}^2}$ = **0.044 gpm/ ft^2**

Answer: d. 0.044 gpm/ ft^2

2. A sand filter measures 40 feet by 30 feet. If the unit needs 15 inches of additional sand ordered, how many cubic feet of sand must be ordered?

a. 1.25 ft^3
b. 9.3 ft^3
c. 1,500 ft^3
d. 18,000 ft^3

What we know:

- This problem asks for the answer to be in ft^3 so we know we need to determine volume.
- Also, the three measurement items indicate we are dealing with a rectangle.
- One of the items is in inches, so we need to convert that to feet before proceeding further.

Step 1: Convert 4 inches into X feet, using the conversion of 12 inches = 1 foot. Let's review conversion principals:

Unknown: X feet =

X feet = $\frac{1 \text{ foot}}{12 \text{ inches}}$ ← *Conversion*

X feet = $\frac{1 \text{ foot}}{12\ \cancel{\text{inches}}}$ x 15 $\cancel{\text{inches}}$ ← *Known*

X feet = 0.0833 feet x 15 = **1.25 feet**

Step 2: The formula that helps us find the volume of a rectangle is as follows:

Volume of a rectangle = (length)(width)(height)

The height we will use is the height of the segment of the area above the filter that needs to be filled.

We plug in the numbers we have:

Volume of a rectangle = (40 feet) (30 feet)(1.25 feet) ⟶ = **1,500 ft^3**

Answer: c. **1,500 ft^3**

3. You have two cylindrical filters – that are set up in series - that are each 20 feet in diameter that are each designed to treat 60 gallons a minute. What is the filter loading rate of these filters in gpm/ft^2?

a. 0.15 gpm/ft^2
b. 0.191 gpm/ft^2
c. 2.3 gpm/ft^2
d. 5.23 gpm/ft^2

Remember: When filters are set up in series (i.e., water passes through one and then the other.) the filter loading rate would be the same as one individual filter.

Step 1: Let's make a list of what we know and what we don't.
Circular filter diameter = 20 feet
Filter flow rate = 60 gpm
Filter loading rate = unknown
Surface area = unknown

Step 2: Find the formula you will use. To determine the filter loading rate we will use that formula (choosing the one that has the flow rate in gpm):

$$\text{Filter Loading Rate (gpm/ ft}^2\text{)} = \frac{\text{Flow Rate (gpm)}}{\text{Surface Area (ft}^2\text{)}}$$

Step 3: Make sure the units are equivalent. In this case, they are not (we need ft^2, which we will get when we determine the surface area) and we need to perform the following calculation.

a. Determine the filter surface area in ft^2. For a circular filter, we use the following equation:

$$\text{Area of Circle} = (0.785)\ (\text{Diameter})^2$$

Let's plug in our circular filter diameter:

$$\text{Area of Circle} = (0.785)\ (20\text{ feet})^2$$

$$\text{Area of Circle} = (0.785)\ (400\ ft^2) \longrightarrow 314\ ft^2$$

Here is our new list of what we know and what we don't:
Flow rate = 60 gpm
Cylindrical filter surface area = 314 ft^2
Filter Loading rate = unknown

Now we can go ahead and plug our numbers into the filter loading rate formula:

$$X\ gpm/ft^2 = \frac{60\ gpm}{314\ ft^2} \longrightarrow 0.191\ gpm/ft^2 \text{ is the filter loading rate}$$

When filters are set up in series (i.e., water passes through one and then the other.) the filter loading rate would be the same as one individual filter, which still means that **0.191 gpm/ft^2 is the filter loading rate of these filters.**

Answer: b. 0.191 gpm/ft^2

Unit 5 Practice #2:

Calculating Ion Exchange Brine Recharge – Example:

An ion exchange unit contains 300 ft^3 of ion exchange resin. Each cubic foot of resin requires 1.5 lbs of salt to recharge the resin. What is the minimum amount of gallons of 10% salt solution needed to achieve regeneration? The salt solution has an active strength of 1 lb/gallon.

a. Approximately 150 gallons
b. Approximately 450 gallons
c. Approximately 1,500 gallons
d. Approximately 4,500 gallons

Step 1: Let's make a list of what we know and what we don't.
Brine (gal) = unknown)
Salt dosage (S) = 1.5 lbs/ft^3
Volume of resin (V) = 300 ft^3
Concentration of brine solution (C) = 1 lb/ gal of 10% salt solution

Step 2: Find the formula you will use. Since we are looking for the volume (in gallons) of brine recharge solution needed, we will use the following formula:

B = SxVx1/C

$$B\ (gal) = \frac{1.5\ \cancel{lbs}/}{\cancel{ft^3}} \times 300\ \cancel{ft^3} \times \frac{1}{1\ \cancel{lb}/\ \text{gal of 10\% salt solution}} = 450\ \text{gal}$$

Note – A gallon in the division in the denominator is equivalent to it being in the numerator.

Answer: b. Approximately 450 gallons

Unit 6

Unit 6 Exercise #1 – Ion Exchange Unit Maintenance

Directions: Choose the correct answer.

1. What type of meter may be used to determine when an ion exchange unit needs to be recharged? (choose the best answer)

a. Chlorine meter

b. Turbidimeter

c. A conductivity meter

d. pH meter

Answer: c. A conductivity meter

2. In order to decrease the amount of hardness ions present in the effluent leaving an ion exchange softener, the flow rate should be _______________.

a. increased

b. decreased

c. kept the same

Answer: a. increased; as the flow rate through an ion exchange unit is increased, more contaminants are removed and the contaminant level in the effluent water leaving the unit decreases.

3. If the regeneration process is not properly performed on an ion exchange unit, it may result in the unit becoming _________ efficient at removing contaminants.

a. more

b. less

Answer: b. less

4. You are troubleshooting why your ion exchange unit seems to need a longer regeneration time; possible factors could be (check all that apply):

a. You have been decreasing your service run times

b. Your system has leaky valves

c. You have been extending your service run times

Answer: b. Your system has leaky valves and c. You have been extending your service run times

5. Ion exchange units are easy to completely recharge, so it's not critical whether or not you follow the manufacturer's recommendations for proper regeneration procedures.

a. True

b. False

Answer: b. False

Unit 6 Exercise #2 – Media Filter Maintenance

Directions: Choose the correct answer.

1. Should the freeboard space of a filter be totally filled?

a. Yes, the more filter media there is in a filter, the more contaminants that can be removed

b. No, because it allows for media bed expansion during the backwashing process

Answer: b. No, because it allows for media bed expansion during the backwashing process

2. Filter backwash is required when contaminants (such as iron or manganese) begin to build up in and break through the filter

a. True

b. False

Answer: a. True

3. Insufficient backwashing causes the thickness of the filter media to increase. For iron and manganese removal, this can cause problems such as (choose all that apply):

a. increased flow through the filter media,

b. failure to remove additional insoluble iron and manganese

c. better cleaning of media during the backwash process.

d. decreased filter run times

Answer: b. failure to remove additional insoluble iron and manganese and d. decreased filter run times

4. The backwash process on an iron and manganese filter produces a waste solution with an elevated level of these contaminants. Backwash water can be disposed of into the storm drain system that leads to a nearby body of water.

a. True

b. False

Answer: b. False

5. As media __________ takes place and the flow through the filter ______ __________, this is an indication that the filter needs to be backwashed.

a. contraction, speeds up

b. expansion, slows down

c. coloring, gets cloudy

Answer: b. expansion, slows down

6. If the finished water from your filter has a turbid appearance, the flow through the filter may need to be _______________.

a. increased

b. decreased

Answer: b. decreased

7. The term “iron filter” usually refers to an oxidizing filter where iron is oxidized by the special coating of manganese oxide that is attached to the ______________ in the filter .

a. greensand

b. polyphosphates

Answer: a. greensand

8. Soaking and cleaning greensand filters in an acidic solution will increase the ion exchange efficiency of the filter.

a. True

b. False

Answer: a. True