Wastewater Sample Problems

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1. What is the volume in cubic feet of a rectangular tank that is 10ft by 30ft by 16ft and how many gallons can fit in it?

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2. What is the volume of a tank in gallons if it is 12 feet deep and has a diameter of 30 feet?

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3. How many hours will it take to fill each tank above if the flow entering them is 1.3MGD?

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4. Your superintendent wants to know how efficient your primary clarifier was at removing solids during a major rain storm a few days earlier. The lab tech tells you that the average 24-hour composite TSS of the sewage entering the primary settling tank on the day in question was 228 ppm, and the average 24-hour composite TSS of the effluent that same day was 87 ppm. What do you tell the superintendent was the approximate percent removal?

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5. What is the mixed liquor suspended solids concentration given the following?

Initial weight of filter disk	*= 0.45 gms*
Volume of filtered sample	*= 60 mls*
Weight of filter disk and filtered residue	*= 0.775 gms*

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6. A wastewater treatment facility has three primary clarifiers available for use. They are all circular clarifiers with a radius of 40ft and a depth of 8ft. The design engineer wants you to maintain a primary clarification detention time of approximately 3.5 hours. How many tanks will you need to use if the plant flow rate is approximately 2MGD?

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7. What is the daily food to microorganism ratio given the following?

Aeration tank 28' x 120' x 15'
Raw sewage flow = 7,500,000
Primary influent BOD = 115 mg/L
Mixed liquor volatile suspended solids (MLVSS) = 4,700 mg/L

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8. Laboratory tests indicate that the volatile content of a raw sludge was 77% and after digestion the content is 41%. The percent reduction of volatile matter is:

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9. Your facility feeds chlorine to the contact tank at a rate of about 280 gallons every day. The plant flow averages about 2.9 MGD. However, due to filamentous bacteria, you must also chlorinate your RAS, using about 20 gallons/day for that purpose. Also, the facility superintendent has about 15 gallons/day of chlorine fed to the head works for odor control in the morning. How much chlorine would be used for disinfection during a 6-hour shift?

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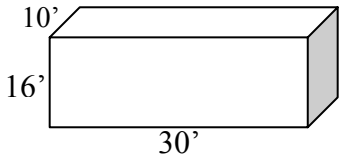
10. How many pounds of solids are under aeration in an aeration tank that is 30' by 70' by 15' and if the MLSS is 3,200 mg/L?

#1. Tank dimensions: 10 feet by 30 feet by 16 feet.



Note: Remember, the unit of feet can be expressed as Ft or with a ’

Vol in FT^3 = (10’)(30’)(16’)

Vol in FT^3 = **4,800 FT^3** ← *Answer*

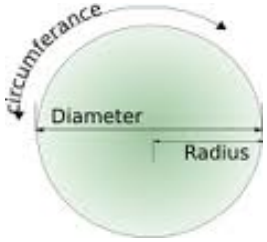
How many gallons can fit in 4,800 FT^3?

Vol in gallons = 4,800 FT^3 (7.48 gal/ FT^3)

Vol in gallons = **35,904 gal** ←*Answer*

← *Note: The unit of FT^3 is in the top of one term and the bottom of the other. That means when these terms are multiplied, the FT^3 units cancel each other out, leaving you with just the unit of gallons on top. Remember, the units help tell you if you’re on the right path.*

Note: This could be “rounded down” on the exam to 35,900 gallons.



#2: Tank dimensions: Depth (or Height) = 12’
Diameter = 30’
Which means the Radius = 15’(that is, half the diameter).

Vol in FT^3 = $(\pi)(R^2)(H)$ *Note: There are two versions of the equation on the formula sheet. You can use either one. Just make sure to use the diameter or radius as noted on the formula sheet.*

Vol in FT^3 = (3.1416)(15 FT)^2(12 FT) = (3.1416)(15 FT)(15 FT)(12 FT)

↑ *Note: When you square the radius, you’re just multiplying it by itself.*

Vol in FT^3 = (3.1416)(225 FT^2)(12 FT)

Vol in FT^3 = **8,482 FT^3** ←*Answer*

How many gallons can fit in 8,482 FT^3?

Vol in gallons = 8,482FT^3 (7.48 gal/FT^3)

Vol in gallons = **63,445 gal** ←*Answer*

#3. How many hours will it take to fill those two tanks with a flow rate of 1.3MGD?

For Tank 1: Vol = 35,900 gallons
Flow = 1.3MGD = 1,300,000 gals/day

Time in days = $\frac{35{,}904 \text{ gallons}}{1{,}300{,}000 \text{ gal/day}}$ = 0.028 days

← Note: The unit of GALLONS is in both the top and bottom of the division line. So when divided together they cancel each other out. But the unit of DAYS is in the "denominator of the denominator," and when you divide by a unit with a denominator, that portion of the unit moves up top, in this case leaving you with just the unit of days.

Time in hours = 0.028days(24hours/day)

Time in hours = **0.66 hours** ←*Answer*

For Tank 1: Vol = 63,445 gallons
Flow = 1.3MGD = 1,300,000 gals/day

Time in days = $\frac{63{,}445 \text{ gallons}}{1{,}300{,}000 \text{ gal/day}}$ = 0.0488 days

Time in hours = 0.0488days(24hours/day)

Time in hours = **1.2 hours** ←*Answer*

#4 Efficiency = $\frac{\text{(Value In – Value Out)(100)}}{\text{Value In}}$

TSS entering the primary clarifier = 228ppm (or 228 mg/L)
TSS leaving the primary clarifier = 87ppm (or 87 mg/L)

Plugging in the numbers:

Efficiency = $\frac{\text{(228ppm – 87ppm)(100)}}{\text{228ppm}} = \frac{\text{(141ppm)(100)}}{\text{228ppm}} = \frac{\text{14,100ppm}}{\text{228ppm}}$

Efficiency = **61.8%** ***←Answer***

#5 *Note: MLSS is the suspended solids of the mixed liquor in the aeration basin.*

Suspended Solids = $\frac{(Wt_2 - Wt_1)(1{,}000{,}000)}{\text{Sample size in mls.}}$

Suspended Solids = $\frac{\text{(0.775gms – 0.45gms)(1,000,000)}}{\text{60 mls}}$ *← Note: While the formula sheet doesn't say so, the 1,000,000 figure is really a conversion factor that changes gms/mls to mgL.*

Suspended Solds = 5,417 mg/L ***←Answer***

#6 The best equation to help here is the Detention Time formula. By using that formula, you will be able to determine the detention time of one tank. Once you know that, you can figure out if you need only one tank, or two, or all three.

Detention Time of one tank = $\frac{\text{(Vol in FT}^3\text{)(7.48 gal/ FT}^3\text{)(24hrs/day)}}{\text{Flow in gal/day}}$

First, figure out the volume of a single primary clarifier:

Vol in FT^3 = $(\pi)(R^2)(H) = (3.1416)(40\,FT)^2(8FT) = 40{,}192\,FT^3$

That means that the Detention Time of one tank = $\frac{\text{(40,192 FT}^3\text{)(7.48gal/ FT}^3\text{)(24hours/day)}}{\text{2,000,000 gal/day}}$

Detention Time of one tank = 3.62 hours

Note: Were you able to follow how most of the units cancelled each other out, leaving you only with the unit of "hours"?

So if the detention time of one tank is about 3.62 hours, and the designer wants only 3.5 hours of primary clarification detention time. That means you only need **one tank to get the 3.5 hours of detention**. ***←Answer***

#7 $\frac{\text{FOOD}}{\text{MASS}} = \frac{\text{(Flow MGD) (Aeration Tank Influent BOD in mg/l)(8.34lb/gal)}}{\text{(MLVSS) (Aeration Tank Volume in MG) (8.34 lb.gal)}}$

First, calculate the Aeration Tank Volume. By now you should be able to take the tank dimensions and calculate the volume in cubic feet (that is, FT^3). Then you should be able to take the volume in FT^3 and convert it to gallons. When you do the math, you get an aeration tank volume of approximately 377,000 gallons. When that volume is expressed in "million gallons," you get 0.377MG.

And so …

$\frac{\text{FOOD}}{\text{MASS}} = \frac{\text{(7.5MGD) (115 mg/l)(8.34lb/gal)}}{\text{(4,700 mg/L) (0.377MG)(8.34 lb.gal)}}$

← Note: This equation shows the conversion of both the top and bottom values into Pounds by multiplying each by 8.34 lb/gal. But since that value is on both the top and bottom, when they're divided, they cancel each other out.

$\frac{\text{FOOD}}{\text{MASS}} = \frac{\text{(7.5MGD) (115 mg/L)}}{\text{(4,700 mg/L) (0.377MG)}}$

← Another note*: This equation is the one equation that makes following the units difficult. So don't worry about unit cancelation as long as you enter every piece of the formula in the units asked for on the formula sheet. The answer for Question #10 gives a little more information about what's going on here.*

$\frac{\text{FOOD}}{\text{MASS}}$ = **0.49** ***←Answer***

#8

Note: In this problem, the volatile content of raw sludge is expressed in a percentage on the scale of 0 – 100. When using that information mathematically in the formula on the formula sheet, you express those values as a percentage on a 0 – 1 scale. So 77% become 0.77 and 41% become 0.41).

Reduction of Volatile Matter (%)

$$= \frac{\text{(Value IN – Value OUT)(100)}}{\text{(Value IN – [(Value IN)(Value OUT)]}}$$

$$= \frac{(0.77 - 0.41)(100)}{(0.77 - [(0.77)(0.41)]}$$

$$= \frac{(0.36)(100)}{(0.77 - 0.315)}$$

$$= \frac{36}{0.45}$$

= **80%** ***←Answer***

#9. This is a problem where you have to consider only what you need to know, and ignore any information you don't care about—because in the real world, sometimes you will have more information than you need. Here, all you really need to pay attention to is what's in the first and last sentence. Everything else doesn't factor into the question.

Chlorine used in 24 hours at the contact tank: 280 gallons.

So to know what you need in 6 hours just for disinfection, you're really just figuring out how many gallons are used in one quarter of the day. (6 hours is ¼ of 24 hours.)

And so, (¼)(280 gallons) = **70 gallons**. ***←Answer***

(OR you could figure out the hourly rate of chlorine used for disinfection, which is 280 gallons divided by 24 hours. That comes out to 11.67 gal/hour. Then you would multiply that by the 6 hours asked for in the question. That comes out to 70 gallons, too. Of course, depending on how you round the numbers, you may get 69.9999999 … which is pretty close to 70!)

#10 This problem requires the "Pounds Formula," which is:

Pounds (Lbs.) = (flow MGD) (mg/l) (8.34 Lbs/Gal)

Note: The formula uses "Flow in MGD," but you can substitute "Volume in MG." And so …

Pounds (Lbs.) = (Vol in MG) (mg/l) (8.34 Lbs/Gal)

So

Pounds (Lbs) = (Vol in MG)(3,200 mg/L)(8.34 Lbs/Gal)

Here we need to figure out the volume in million gallons.

Vol in FT^3 = (30')(70')(15') = 31,500 FT^3

Vol in gal = (31,500 FT^3)(7.48 gal/ FT^3) = 235,620 gallons = 0.236 MG

Therefore, if Pounds (Lbs) = (Vol in MG)(3,200 mg/L)(8.34 Lbs/Gal)

Then, Pounds (Lbs) = (0.236MG)(3,200 mg/L)(8.34 Lbs/Gal)

Pounds (Lbs) = **6,298 Lbs**. ***←Answer***

Note: If you're wondering about how the units cancel out in this problem, remember that "mg/L" can also be represented as "ppm," or "parts per million." So when the "Million Gallon" value is multiplied by a "part per million" value, the "millions" cancel each other out. The gallons cancel each other out, too, leaving you with just Lbs.