INTERMEDIATE WATER MATH

Sidney Innerebner, PhD, PE
Principal / Owner

INDIGO WATER GROUP
626 West Davies Way
Littleton, Colorado 80120
Sidney@indigowatergroup.com 303-489-9226

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Math Problem Solving Strategy

1. Read the question carefully and underline what they are asking you to find.
2. Write down the formula you need to solve the problem. Look in the front of the test booklet if necessary.
3. Fill in everything you know. Sometimes filling in what you know might require you to find something else first like area or volume.
4. Check your units! Make sure they are correct for the formula and agree with eachother.
5. Convert units where needed.
6. Put the new units into the formula.
7. Solve.
8. Check the units of your answer. Are they what the question asked for?
9. Convert units if necessary.

ABC Formula/Conversion Table for Water Treatment, Distribution and Laboratory Exams

Alkalinity, as mg $CaCO_3$/L = $\frac{\text{(Titrant Volume, mL) (Acid Normality) (50,000)}}{\text{Sample Volume, mL}}$

Amps = $\frac{\text{Volts}}{\text{Ohms}}$

Area of Circle = (.785) (Diameter^2) or (Π) (Radius^2)

Area of Cone (lateral area) = (Π) (Radius) $\sqrt{\text{Radius}^2 + \text{Height}^2}$

Area of Cone (total surface area) = (Π) (Radius) (Radius + $\sqrt{\text{Radius}^2 + \text{Height}^2}$)

Area of Cylinder (total outside surface area) = [Surface Area of End #1] + [Surface Area of End #2] + [(Π) (Diameter) (Height or Depth)]

Area of Rectangle = (Length) (Width)

Area of a Right Triangle = $\frac{\text{(Base) (Height)}}{2}$

Average (arithmetic mean) = $\frac{\text{Sum of All Terms}}{\text{Number of Terms}}$

Average (geometric mean) = $[(X_1)(X_2)(X_3)(X_4)(X_n)]^{1/n}$ The *n*th root of the product of *n* numbers

Chemical Feed Pump Setting, % Stroke = $\frac{\text{(Desired Flow) (100\%)}}{\text{Maximum Flow}}$

Chemical Feed Pump Setting, mL/min = $\frac{\text{(Flow, MGD) (Dose, mg/L) (3.785 L/gal) (1,000,000 gal/MG)}}{\text{(Liquid, mg/mL) (24 hr/day) (60 min/hr)}}$

Circumference of Circle = (Π) (Diameter)

Composite Sample Single Portion = $\frac{\text{(Instantaneous Flow) (Total Sample Volume)}}{\text{(Number of Portions) (Average Flow)}}$

Degrees Celsius = [(Degrees Fahrenheit - 32) ($^5/_9$)] or $\frac{(^\circ F - 32)}{1.8}$

Degrees Fahrenheit = [(Degrees Celsius) ($^9/_5$) + 32] or [(Degrees Celsius) (1.8) + 32]

Detention Time = $\frac{\text{Volume}}{\text{Flow}}$ Note: Units must be compatible.

Electromotive Force (E.M.F), volts = (Current, amps) (Resistance, ohms) or E =IR

Feed Rate, lbs/day = $\frac{\text{(Dosage, mg/L) (Capacity, MGD) (8.34 lbs/gal)}}{\text{(Purity, decimal percentage)}}$

$$\text{Feed Rate, gal/min (Fluoride Saturator)} = \frac{(\text{Plant capacity, gal/min})(\text{Dosage, mg/L})}{(18{,}000 \text{ mg/L})}$$

$$\text{Filter Backwash Rise Rate, in/min} = \frac{(\text{Backwash Rate, GPM/sq ft})(12 \text{ in/ft})}{(7.48 \text{ gal/cu ft})}$$

$$\text{Filter Drop Test Velocity, ft/min} = \frac{\text{Water Drop, ft}}{\text{Time of Drop, min}}$$

$$\text{Filter Flow Rate or Backwash Rate, gpm/sq ft} = \frac{\text{Flow, gpm}}{\text{Filter Area, sq ft}}$$

$$\text{Filter Yield, lbs/hr/sq ft} = \frac{(\text{Solids Loading, lbs/day})(\text{Recovery, \% / 100\%})}{(\text{Filter operation, hr/day})(\text{Area, sq ft})}$$

Flow Rate, cfs = (Area, sq ft) (Velocity, ft/sec) or $Q = AV$ where: Q = flow rate, A = area, V= velocity

Force, pounds = (Pressure, psi) (Area, sq in)

$$\text{Gallons/Capita/Day} = \frac{\text{Volume of Water Produced, gpd}}{\text{Population}}$$

$$\text{Hardness, as mg } CaCO_3/L = \frac{(\text{Titrant Volume, mL})(1{,}000)}{\text{Sample Volume, mL}}$$ Only when the titration factor is 1.00 of EDTA

$$\text{Horsepower, Brake (bhp)} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{(3{,}960)(\text{Decimal Pump Efficiency})}$$

$$\text{Horsepower, Motor (mhp)} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{(3{,}960)(\text{Decimal Pump Efficiency})(\text{Decimal Motor Efficiency})}$$

$$\text{Horsepower, Water (whp)} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{3{,}960}$$

$$\text{Hydraulic Loading Rate} = \frac{\text{Total Flow Applied, gpm}}{\text{Area, sq ft}}$$

$$\text{Hypochlorite Strength, \%} = \frac{(\text{Chlorine Required, lbs})(100)}{(\text{Hypochlorite Solution Needed, gal})(8.34 \text{ lbs/gal})}$$

$$\text{Leakage, gpd} = \frac{\text{Volume, gallons}}{\text{Time, days}}$$

Mass Flux, lbs/day = (Flow, MGD) (Concentration, mg/L) (8.34 lbs/gal)

Mass, lbs = (Volume, MG) (Concentration, mg/L)(8.34 lbs/gal)

Milliequivalent = (mL) (Normality)

$$\text{Molarity} = \frac{\text{Moles of Solute}}{\text{Liters of Solution}}$$

$$\text{Normality} = \frac{\text{Number of Equivalent Weights of Solute}}{\text{Liters of Solution}}$$

$$\text{Number of Equivalent Weights} = \frac{\text{Total Weight}}{\text{Equivalent Weight}}$$

$$\text{Number of Moles} = \frac{\text{Total Weight}}{\text{Molecular Weight}}$$

$$\text{Reduction in Flow, \%} = \frac{(\text{Original Flow - Reduced Flow})(100\%)}{\text{Original Flow}}$$

$$\text{Removal, \%} = \frac{(\text{In} - \text{Out})(100)}{\text{In}}$$

$$\text{Slope, \%} = \frac{\text{Drop or Rise}}{\text{Distance}} \times 100$$

$$\text{Solids, mg/L} = \frac{(\text{Dry Solids, grams})(1{,}000{,}000)}{\text{Sample Volume, mL}}$$

$$\text{Solids Concentration, mg/L} = \frac{\text{Weight, mg}}{\text{Volume, L}}$$

$$\text{Specific Gravity} = \frac{\text{Specific Weight of Substance, lbs/gal}}{\text{Specific Weight of Water, lbs/gal}}$$

$$\text{Surface Loading Rate/Surface overflow rate, gpd/sq ft} = \frac{\text{Flow, gpd}}{\text{Area, sq ft}}$$

Three Normal Equation = $(N_1 \times V_1) + (N_2 \times V_2) = (N_3 \times V_3)$, where $V_1 + V_2 = V_3$

Two Normal Equation = N1 x $V_1 = N_2 \times V_2$, where N = normality, V = volume or flow

$$\text{Velocity, ft/sec} = \frac{\text{Flow Rate cu ft / sec}}{\text{Area, sq ft}} \text{ or } \frac{\text{Distance, ft}}{\text{Time, sec}}$$

Volume of Cone = (1/3) (.785) (Diameter^2) (Height)

Volume of Cylinder = (.785) (Diameter^2) (Height)

Volume of Rectangular Tank = (Length) (Width) (Height)

Watts (AC circuit) = (Volts) (Amps) (Power Factor)

Watts (DC circuit) = (Volts) (Amps)

$$\text{Weir Overflow Rate, gpd/ft} = \frac{\text{Flow, gpd}}{\text{Weir Length, ft}}$$

$$\text{Wire-to-Water Efficiency, \%} = \frac{\text{Water Horsepower, HP}}{\text{Power Input, HP or Motor HP}} \times 100$$

$$\text{Wire-to-Water Efficiency, \%} = \frac{(\text{Flow, gpm})(\text{Total Dynamic Head, ft})(0.746\text{ kw/hp})(100)}{(3{,}960)(\text{Electrical Demand, kilowatts})}$$

Alkalinity Relationships:

Result of Titration	Alkalinity, mg/L as $CaCO_3$ Hydroxide Alkalinity as $CaCO_3$	Carbonate Alkalinity as $CaCO_3$	Bicarbonate Concentration as $CaCO_3$
P = 0	0	0	T
P < ½T	0	2P	T – 2P
P = ½T	0	2P	0
P > ½T	2P – T	2(T – P)	0
P = T	T	0	0

*Key: P – phenolphthalein alkalinity; T – total alkalinity

Conversion Factors:

1 acre = 43,560 square feet
1 acre foot = 326,000 gallons
1 cubic foot = 7.48 gallons
1 cubic foot = 62.4 pounds
1 cubic foot per second = 0.646 MGD
1 foot = 0.305 meters
1 foot of water = 0.433 psi
1 gallon = 3.79 liters
1 gallon = 8.34 pounds
1 grain per gallon = 17.1 mg/L
1 horsepower = 0.746 kW or 746 watts or 33,000 ft. lbs./min.
1 mile = 5,280 feet
1 million gallons per day = 694 gallons per minute
1 million gallons per day = 1.55 cubic feet per second (cfs)
1 pound = 0.454 kilograms
1 pound per square inch = 2.31 feet of water
1 ton = 2,000 pounds
1% = 10,000 mg/L
Π or pi = 3.14

Abbreviations:

cfs	cubic feet per second	MGD	million gallons per day
DO	dissolved oxygen	mL	milliliter
ft	feet	ppb	parts per billion
g	grams	ppm	parts per million
gpd	gallons per day	psi	pounds per square inch
gpg	grains per gallon	Q	flow
gpm	gallons per minute	SS	settleable solids
in	inches	TTHM	Total trihalomethanes
kW	kilowatt	TOC	total organic carbon
lbs	pounds	TSS	total suspended solids
mg/L	milligrams per liter	VS	volatile solids

Unit Conversions

1. Convert 20 gpm to mgd

2. Convert 60 mph to ft/second

3. Convert 6000 cf to gallons

4. Convert 7 days into seconds

5. Convert 120 feet of static head into psi

6. Convert 14 acres into square feet

7. Convert 3 cubic yards into gallons

8. Convert 1 acre-ft/day into gpm

9. Convert 15 cfs into gpm

10. Convert 3 mgd to cfs

11. Convert 400 psi into feet of head

12. Convert 30 HP into kW. If this piece of equipment runs for 80 hours and electricity costs $0.07 per kilowatt hour, what will it cost?

13. Convert 144 square inches into square feet

14. Convert 20 gal/sf to liters per square meter

15. A tank contains 20 feet of water and is 10 feet in diameter. What is the pressure in psi at the bottom of the tank?

Tank Geometry

16. The diameter of a wet well is 10 feet. If filled to a depth of 12 feet, it will contain approximately how many gallons of water?

17. How many gallons of liquid can be held by a tank that measures 40 feet long by 25 feet wide by 12 feet deep?

18. Approximately how many gallons would 600 feet of 6-inch diameter pipe hold?

19. A cylindrical water tank must be painted both inside and out. All surfaces, except the bottom of the tank where it contacts the ground, must be painted. If the tank is 20 feet tall and 60 feet in diameter, how many square feet must be painted?

20. A water storage tank holds 323,136 gallons. If the water depth in the tank is 12 feet, what is the area of the tank is square feet?

21. The inside walls and bottom of a concrete tank must be painted. The floor of the tank is 25 feet long by 15 feet wide. If the tank is 12 feet deep and does not have a top, how many square feet must be painted?

22. How many gallons does a 400 foot long section of 24-inch pipe hold?

23. The distribution system has 3 storage tanks. Each tank is 50 feet square and 30 feet deep. What is the maximum storage volume of the distribution system in gallons?

24. Find the perimeter of a circular sedimentation basin if the basin is 30 feet in diameter.

25. A 24 foot diameter tank has a conical bottom. The sidewater depth (top of cone to water surface level) is 20 feet. The cone is 6 feet deep at its deepest point. What is the volume of the cone in cubic feet?

Hydraulic Retention Time

26. A tank holds 500 gallons. A pump is used to fill the tank at a rate of 25 gpm. How long will it take to fill the tank?

27. A finished water storage tank is 35 feet in diameter and 65 feet high. With no water entering the tank, the water level dropped 14 feet in 5 hours. Find the average rate of flow for water leaving the tank in gallons per minute.

28. If two pumps transfer 120 gpm each, how long will it take to fill a tank 50 feet long, 20 feet wide, and 8 feet deep? Express your answer in hours and minutes.

29. What is the average detention time in a basin given the following: diameter is 65 feet, depth is 12 feet, influent flow is 700 gpm.

30. A settling basin that is 60 feet long, 15 feet wide, and 12 feet deep is used to treat a flow of 2.4 mgd. What is the detention time?

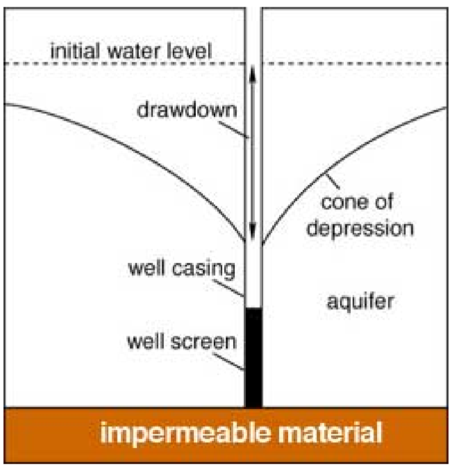
31. What is the detention time in days for a reservoir if the influent flow rate is 0.785 mgd, the reservoir covers 17 acres, and has an average depth of 22 feet?

32. A water main feeds a subdivision. The main is 500 feet long and 12-inches in diameter. The pipe delivers an average flow of 30 cfm. The distribution crew is flushing the main to remove sediment. How long should they flush the line to achieve 2 pipe volumes?

33. A rectangular basin measures 100 feet long by 50 feet wide by 12 feet deep. A pump drawing water out of the tank is able to empty the tank in 1.24 days. What is the pump rate in gpm?

34. Determine the flow capacity of a pump in gpm if the pump lowers the water is a six-foot square wet well by 8 inches in 5 minutes.

Wells



35. A well is drilled through an unconfined aquifer. The top of the aquifer is 80 feet below grade. After the well was in service for a year, the water level in the well stabilized at 110 feet below grade. What is the drawdown?

36. A well produces 300 gpm. If the drawdown is 30 feet, find the specific yield.

37. The specific yield for a well is 10 gpm/ft. If the well produces 550 gpm, what is the drawdown?

38. The pumped water level of a well is 400 feet below the surface. The well produces 350 gpm. If the aquifer level is 250 feet below the surface, what is the specific yield for the well?

Force

39. Find the force on a 12-inch valve if the water pressure within the line is 60 psi. Express your answer in tons.

40. A 42-inch main line has a shut off valve. The same line has a 10-inch bypass line with another shut-off valve. Find the amount of force on each valve if the water pressure in the line is 80 psi. Express your answer in tons.

41. A water tank is 15 feet deep and 30 feet in diameter. What is the force exerted on a 6-inch valve at the bottom of the tank?

Velocity

42. A 42-inch diameter pipe transfers 35 cubic feet of water per second. Find the velocity in ft/sec.

43. A plastic float is dropped into a channel and is found to travel 10 feet in 4.2 seconds. The channel is 2.4 feet wide and 1.8 feet deep. Calculate the flow rate of water in cfs.

44. The flow velocity of a 6-inch diameter pipe is twice that of a 12-inch diameter pipe if both are carrying 50 gpm of water. True or false?

45. What should the flow meter read in gpm if a 4-inch diameter main is to be flushed at a velocity of 4.6 fps?

46. The velocity through a channel is 4.18 fps. If the channel is 4 feet wide by 2 feet deep by 10 feet long, what is the flow rate in gpm?

47. What is the average flow velocity in ft/sec for a 12-inch diameter main carrying a daily flow of 2.5 mgd?

Pumps

48. Water is being pumped from a reservoir to a storage tank on a hill. The elevation difference between water levels is 1200 feet. Find the pump size required to fill the tank at a rate of 120 gpm. Express your answer in horsepower.

49. A 25 hp pump is used to dewater a lake. If the pump runs for 8 hours a day for 7 days a week, how much will it cost to run the pump for one week? Assume energy costs $0.07 per kilowatt hour.

50. A pump station is used to lift water 50 feet above the pump station to a storage tank. The pump rate is 500 gpm. If the pump has an efficiency of 85% and the motor has an efficiency of 90%, find each of the following: Water Horsepower, Brake Horsepower, Motor Horsepower, and Wire-to-Water Efficiency.

51. A chemical feed pump with a 6-inch bore and a 6-inch stroke pumps 60 cycles per minute. Find the pumping rate in gpm.

52. Determine the flow capacity of a pump in gpm if the pump lowers the water level in a 6-foot square wet well by 8 inches in 5 minutes.

53. Find the brake horsepower for a pump given the following information: Total Dynamic Head = 75 feet, Pump Rate = 150 gpm, Pump Efficiency = 90%, Motor Efficiency = 85%

54. How much will it cost to run the pump in #53 for one year if the pump runs 12 hours a day, 365 days a year? Assume energy costs $0.08 per kilowatt hour.

55. A single-piston reciprocating pump has a 4-inch diameter piston and an 8-inch stroke length. If makes 16 discharge strokes per minute. Find the pumping rate in gpm.

56. After calibrating a chemical feed pump, you've determined that the maximum feed rate is 178 mL/ minute. If this pump ran continuously, how many gallons will it pump in a full day?

Disinfection and Chemical Dosing

57. Determine the chlorinator setting in pounds per day if a water plant produces 300 gpm and the desired chlorine dose is 2.0 mg/L.

58. The finished water chlorine demand is 1.2 mg/L and the target residual is 2.0 mg/L. If the plant flow is 5.6 mgd, how many pounds per day of 65% hypochlorite solution will be required?

59. Fluoride is added to finished water at a dose of 4 mg/L. Find the feed rate setting for a fluoride saturator in gal/min if the water plant produces 5 mgd.

60. If chlorine costs $0.21 per pound, what is the daily cost to chlorinate a 5 mgd flow rate at a dosage of 2.6 mg/L?

61. One gallon of sodium hypochlorite laundry bleach, with 5.25% available chlorine, contains how many pounds of active chlorine?

62. How much sodium hypochlorite, in gallons, is required to obtain a residual of 100 mg/L in a well? The casing diameter is 18-inches and the length is 80 feet. Sodium hypochlorite contains 5.25% available chlorine. Assume a demand of 15 mg/L.

63. A water company uses an average of 600 gpm of water. The water contains 0.30 mg/L of manganese and 0.06 mg/L of iron. How many pounds of iron and manganese are pumped into the distribution system each year?

64. How many pounds of copper sulfate will be needed to dose a reservoir with 0.6 mg/L of copper? The reservoir holds 30 million gallons. The copper sulfate is 25% copper by weight.

65. Liquid alum delivered to a water treatment plant contains 642.3 milligrams of aluminum per milliliter of liquid solution. Jar tests indicate that the best alum dose is 9 mg/L. Determine the setting on the liquid alum feeder in ml/min when the plant flow is 3.2 mgd.

66. The raw water supply contains 1.8 mg/L of fluoride. The flow rate is 400 gpm. The target fluoride dose for the finished water is 3 mg/L. Find the desired feed rate in gpm for a fluoride saturator.

67. The raw water alkalinity is 50 mg/L as calcium carbonate. The water is treated by adding 15 mg/L of alum. What is the alkalinity of the finished water?

Filters

68. A water plant has three filters. Each filter is 12 feet wide by 12 feet long. Find the hydraulic loading rate in gpm/sf when all three filters are on-line and the raw water enters the plant at 9.5 mgd.

69. A sand filter will be backwashed at a rate of 8 gpm/sf. If the filter is 10 feet wide by 15 feet long, what will the filter backwash rise rate be in inches per minute?

70. A series of filters must be backwashed. Each filter is 20 feet square. If the goal is to achieve a filter backwash rise rate of 30 inches per minute, what should the backwash rate be in gpm/sf?

71. A water plant has 3 filters. The plant is currently treating 5 mgd. If each filter is 12 feet wide by 20 feet long, what is the minimum number of filters that should be placed into service to keep the hydraulic loading rate below 20 gpm/sf?

72. Find the yield for a filter in lbs/hr/sf given the following information: Filter operates for 12 hours of each day and captures 95% of the influent solids. The solids load to the filter is 200 pounds per day. The filter is 40 feet square.

73. Coagulated raw water contains 120 mg/L of total suspended solids. The water plant produces 2.0 mgd and has two sand filters that are 20 feet wide by 20 feet long. If the filters operate 22 hours of each day and capture 99% of the coagulated solids, what is the filter yield in lbs/hr/sf? What is the filter yield total in pounds per day?

74. A series of filters discharge into a combined effluent trough. The trough is 5 feet wide by 80 feet long. A weir runs the full length of the trough. If the water plant capacity is 2 mgd, what is the weir overflow rate in gpd/sf?

Dilutions

75. A lab technician needs to make a 50 mg/L standard. Looking in the cabinet, they find a stock solution that is 1,000 mg/L. If the technician uses a 250 mL flask to make the standard, how many milliliters of stock solution will they need?

76. An arsenic standard is left sitting out on the counter without a lid for several days. In the beginning, the bottle had 150 mL of a 10,000 mg/L solution. After four days, the bottle only contained 120 mL. What is the new concentration of arsenic? Assume that arsenic does not evaporate.

77. Some polymer is being added to coagulate solids. It is added in the pipeline between the raw water intake and flocculation basin. The target dose is 25 mg/L and the influent flow rate is 7.74 cfs. If the raw chemical in the feeder tank is 5,000 mg/L, what should the pump rate be in gpm to achieve the desired dose.

78. Ferric chloride is being added as a coagulant to the raw water entering a plant. Sampling shows that the concentration of ferric in the raw water is 25 ppm. A quick check of the chemical metering pump shows that it is operating at a flow rate of 4.3 gpm. If the flow through the water plant is 800 gpm, what is the concentration of raw chemical in the dosing tank?

79. A water plant is fed by two different wells. The first well produces water at a rate of 600 gpm and contains arsenic at 0.5 mg/L. The second well produces water at a rate of 350 gpm and contains arsenic at 12.5 mg/L. What is the arsenic concentration of the blended water?

80. Liquid polymer is delivered as an 8 percent solution. How many gallons of liquid polymer should be mixed in a tank to produce 150 gallons of 0.6 percent solution?

81. There are two raw water lines feeding a water plant. One line carries a flow rate of 500 gpm with a TDS concentration of 1500 mg/L. The second line has a flow rate of 6 mgd with a a 250 mg/L TDS concentration. What is the actual combined TDS concentration entering the plant?

82. Two wells are used to satisfy demand during the summer months. One well produces water that contains 22 mg/L of Arsenic. The other well produces water that contains 3 mg/L of Arsenic. If the total demand for water is 400 gpm and the target Arsenic concentration in the finished water is 8 mg/L, what is the highest pumping rate possible for the first well?

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1. $$\frac{20\text{ gal}}{\text{min}} \times \frac{1440\text{ min}}{1\text{ day}} \times \frac{1\text{ MG}}{1{,}000{,}000\text{ gal}} = 0.0288\ \frac{\text{MG}}{\text{D}}$$

2. $$\frac{60\text{ miles}}{\text{hour}} \times \frac{1\text{ hr}}{60\text{ min}} \times \frac{1\text{ min}}{60\text{ sec}} \times \frac{5280\text{ ft}}{1\text{ mile}} = 88\ \frac{\text{ft}}{\text{sec}}$$

3. $$6{,}000\text{ cf} \times \frac{7.48\text{ gal}}{1\text{ cf}} = 44{,}800\text{ gal}$$

4. $$7\text{ days} \times \frac{1440\text{ min}}{1\text{ day}} \times \frac{60\text{ sec}}{1\text{ min}} = 604{,}800\text{ sec}$$

5. $$120\text{ ft} \times \frac{0.433\text{ psi}}{1\text{ ft}} = 51.96\text{ psi}$$

6. $$14\text{ acres} \times \frac{43{,}560\text{ sf}}{1\text{ acre}} = 609{,}840\text{ sf}$$

7. $$3\text{ cy} \times \frac{27\text{ cf}}{1\text{ cy}} \times \frac{7.48\text{ gal}}{1\text{ cf}} = 606\text{ gal}$$

8. $$1\ \frac{\text{acre}\cdot\text{ft}}{\text{day}} \times \frac{43{,}560\text{ sf}}{1\text{ acre}} \times \frac{7.48\text{ gal}}{1\text{ cf}} \times \frac{1\text{ day}}{1440\text{ min}} = 226\ \frac{\text{gal}}{\text{min}}$$

$$1\ \frac{\text{acre}\cdot\text{ft}}{\text{day}} \times \frac{326{,}000\text{ gal}}{1\text{ acre}\cdot\text{ft}} \times \frac{1\text{ day}}{1440\text{ min}} = 226\ \frac{\text{gal}}{\text{min}}$$

9. $$15\ \frac{\text{cf}}{\text{s}} \times \frac{7.48\text{ gal}}{1\text{ cf}} \times \frac{60\text{ sec}}{1\text{ min}} = 6732\text{ gpm}$$

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10. $\frac{3\ mg}{day} \times \frac{1{,}000{,}000\ gal}{1\ mg} \times \frac{1\ cf}{7.48\ gal} \times \frac{1\ day}{1440\ min} \times \frac{1\ min}{60\ sec} = 4.64\ \frac{cf}{s}$

11. $400\ psi \times \frac{1\ ft}{0.433\ psi} = 923\ ft$

12. $30\ HP \times \frac{0.746\ kW}{1\ HP} \times \frac{\$0.07}{1\ kWH} \times 80\ hrs = \$125.33$

13. $144\ in^2 \times \frac{1\ ft}{12\ in} \times \frac{1\ ft}{12\ in} = 1\ sf$

14. $\frac{20\ gal}{sf} \times \frac{3.785\ L}{1\ gal} \times \frac{10.76\ sf}{1\ m^2} = 814\ L/m^2$

15. $20\ feet \times \frac{0.433\ psi}{1\ ft} = 8.66\ psi$

16. $V = (0.785)(d^2)(h)$
$V = (0.785)(10^2)(12)$
$V = 942\ cf$

$942\ cf \times \frac{7.48\ gal}{1\ cf} = 7{,}046\ gal$

17. $V = l \cdot h \cdot w$
$V = (40\ ft)(25\ ft)(12\ ft)$
$V = 12{,}000\ cf$

$12000\ cf \times \frac{7.48\ gal}{1\ cf} = 89{,}760\ gal$

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18. 6 inches = 0.5 ft

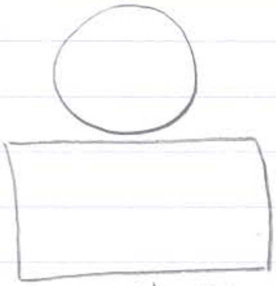
$V = 0.785(d^2)h$

$V = (0.785)(0.5\ ft)^2(600\ ft)$

$V = 117.75\ cf$

$117.75\ cf \left| \frac{7.485}{1\ cf} \right| = 881$ gallons

19.



Area of Top $= (0.785)(d^2)$
$= (0.785)(60\ ft)^2$
$= 2826\ ft^2$

length = Perimeter of tank $= \pi d$

Area of Rectangle $= l \cdot w$
$= (\pi d) \cdot w$
$= (\pi)(60\ ft)(20\ ft)$
$= 3768$ sf

3 - "tops"
2 - sides

2826
2826
2826
3768
+ 3768
~~[illegible]~~ sf
16,014

20. $V = (0.785)(d^2)(h)$
323,136 gallon $= (0.785)(d^2)(20\ ft)$

↑ need to change units to cf

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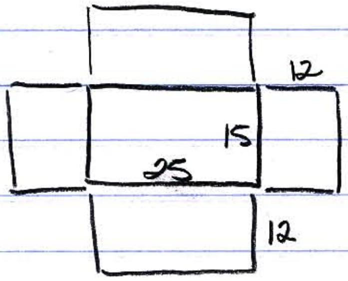
20. 323,126 gallons | $\frac{1 \text{ cf}}{7.48 \text{ gal}}$ | = 43,198.7 cf

$V = \pi d^2 h$ — (πd^2) this is area

43,198.7 cf = (Area)(12 ft)

3600 sf = Area

21.



Area = l · w
Area = (12 ft)(25 ft)
Area = 300 sf
} long side

Area = l · w
Area = (12 ft)(15 ft)
Area = 180 sf
} short side

300
300
180
180
\+ 375
1,335 sf TOTAL

Area = l · w
Area = (15 ft)(25 ft)
Area = 375 sf
} bottom

22. Units don't match, so convert
24 inches = 2 feet

$V = (0.785)(d^2)(h)$
$V = (0.785)(2\text{ft})^2(400\text{ft})$
$V = 1256 \text{ ft}^3$

1256 ft^3 | $\frac{7.48 \text{ gal}}{1 \text{ ft}^3}$ | = 9,395 gallons

23. Volume = length × height × width

Volume = (50 ft)(50 ft)(30 ft)

Volume = 75,000 cf

$75{,}000\ cf \left| \frac{7.48\ gal}{1\ cf} \right| = 561{,}000$ gallons

~ there are 3 tanks, so 3 × 561,000 gal = 1,683,000 gal

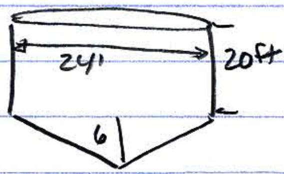
24. Perimeter = Circumference

$P = \pi d$

$P = (3.14)(30 ft)$

$P = 94.2$ ft

25.



$V_{TOP} = 0.785 d^2 h$

$= (0.785)(24\ ft)^2(20\ ft)$

$= 9043.2$ cf

$V_{BOTTOM} = \frac{0.785 d^2 h}{3}$

$= \frac{(0.785)(24\ ft)^2(6\ ft)}{3}$

$= 904.3$ cf

  9043.2 cf
+ 904.3 cf
9947.5 cf

26. DETENTION TIME = $\frac{\text{VOLUME}}{\text{FLOW}}$

TIME = $\frac{500 \text{ gallons}}{25 \text{ gpm}}$

TIME = 20 minutes

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27. $TIME = \frac{VOLUME}{FLOW}$

↗ FIND VOLUME IN GALLONS FIRST

$Volume = 0.785 d^2 h$

$= (0.785)(35 ft)^2(14 ft)$

$= 13462.75$ cf

$13462.75 \text{ cf} \left| \frac{7.48 \text{ gal}}{1 \text{ cf}} \right| = 100,701$ gal

$TIME = \frac{VOLUME}{FLOW}$

$5 \text{ HRS} = \frac{100,701 \text{ gal}}{FLOW}$

$(5)(FLOW) = 100,701$ gal

$FLOW = 20,140 \frac{gal}{hr}$ ← they asked for gpm

$20,140 \frac{gal}{hr} \left| \frac{1 hr}{60 min} \right| = 336$ gpm

28. $V = l \cdot w \cdot h$

$V = (50 ft)(20 ft)(8 ft)$

$V = 8,000$ cf

$8,000 \text{ cf} \left| \frac{7.48 \text{ gal}}{1 \text{ cf}} \right| = 59840$ gal

$TIME = \frac{VOLUME}{FLOW}$

$TIME = \frac{59,840 \text{ gal}}{240 \text{ gpm}}$

TIME = 249 minutes

249 minutes is also 4 hours 9 minutes

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29. $V = 0.785 d^2 h$

$V = (0.785)(65 ft)^2(12 ft)$

$V = 39{,}799.5$ cf

$39{,}799.5 \text{ cf} \times \frac{7.48 \text{ gal}}{1 \text{ cf}} = 297{,}700$ gallons

$\text{time} = \frac{V}{Q}$

$\text{time} = \frac{297{,}700 \text{ gallons}}{700 \text{ gpm}}$

time = 425 minutes ⟶ 7 hours 5 mins.

30. $V = l \cdot w \cdot h$

$V = (60 ft)(15 ft)(12 ft)$

$V = 10{,}800$ cf

$10{,}800 \text{ cf} \times \frac{7.48 \text{ gal}}{1 \text{ cf}} = 80{,}784$ gal

$\text{TIME} = \frac{\text{VOLUME}}{\text{FLOW}}$

$\text{TIME} = \frac{80{,}784 \text{ gallon}}{2{,}400{,}000 \text{ gpd}}$

TIME = 0.03366 days

$0.03366 \text{ days} \times \frac{24 \text{ hrs}}{1 \text{ day}} \times \frac{60 \text{ min}}{1 \text{ hr}} = 48$ minutes

31. 17 acres × 22 ft = 374 acre·ft

$374 \text{ acre·ft} \times \frac{326{,}000 \text{ gal}}{1 \text{ acre·ft}} \times \frac{1 \text{ MG}}{1000000 \text{ gal}} = 121.9$ MG

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31. (cont.) $\text{TIME} = \frac{\text{Volume}}{Q}$

$\text{TIME} = \frac{121.9\ \text{MG}}{0.785\ \text{MGD}}$

$\text{TIME} = 155$ days

32. $V = 0.785 d^2 h$ 12 inches = 1 ft

$V = (0.785)(1\ \text{ft})^2(500\ \text{ft})$

$V = 392.5$ cf

so 2 pipe volumes = (2)(392.5 cf) = 785 cf

$\text{TIME} = \frac{\text{Volume}}{\text{Flow}}$

$\text{TIME} = \frac{785\ \text{cf}}{30\ \text{cfm}}$

$\text{TIME} = 26$ minutes

33. $V = l \cdot w \cdot h$

$V = (50\ \text{ft})(100\ \text{ft})(12\ \text{ft})$

$V = 60{,}000$ cf

$60{,}000\ \text{cf} \left| \frac{7.48\ \text{gal}}{1\ \text{cf}} \right| = 448{,}800$ gal

$\text{TIME} = \frac{V}{Q}$

$1.24\ \text{days} = \frac{448{,}800\ \text{gal}}{Q}$

$(1.24\ \text{days})(Q) = 448{,}800$ gal

$Q = 361{,}935 \frac{\text{gal}}{\text{day}}$

$361{,}935 \frac{\text{gal}}{\text{day}} \left| \frac{1\ \text{d}}{1440\ \text{min}} \right| = 251$ gpm

34. 8 inches = 0.67 ft

$V = l \cdot w \cdot h$

$V = (6ft)(6ft)(0.67ft)$

$V = 24.12\ ft^3$

$24.12\ ft^3 \left| \frac{7.48\ gal}{1\ ft^3} \right| = 180.4\ gal$

$Time = \frac{V}{Q}$

$5\ min = \frac{180.4\ gal}{Q}$

$(Q)(5) = (180.4)$

$Q = 36\ \frac{gal}{min}$

35. DRAWDOWN = INITIAL − PUMPING

= 80 ft − 110 ft

DRAWDOWN = 30 feet

36. $\text{Specific Yield} = \frac{\text{Yield}}{\text{Drawdown}}$

$= \frac{300\ gpm}{30\ ft}$

$= 10\ gpm/ft$

37. $\text{Specific Yield} = \frac{\text{Yield}}{\text{Drawdown}}$

$10\ gpm/ft = \frac{550\ gpm}{\text{Drawdown}}$

$(10)(\text{Drawdown}) = 550$

Drawdown = 55 ft

38. 400 ft
− 250 ft
150 ft drawdown

$\text{Specific Yield} = \frac{\text{Yield}}{\text{Drawdown}}$

$= \frac{350\ gpm}{150\ ft}$

$= 2.3\ gpm/ft$

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39. FORCE = PRESSURE × AREA

up until now, we've always converted inches into feet. With this equation we want inches because pressure is in pounds per square inch

AREA = 0.785 d^2
= (0.785)(12 in)^2
= 113 in^2

FORCE = Pressure × AREA
FORCE = (60 psi)(113 in^2)
FORCE = 6782.4 lbs

$6782.4 \text{ lbs} \left| \frac{1 \text{ ton}}{2000 \text{ lbs}} \right| = 3.39 \text{ tons}$

40. AREA = 0.785 d^2
= (0.785)(42 inches)^2
= 1,384 in^2

AREA = 0.785 d^2
= (0.785)(10 inches)^2
= 78.5 in^2

FORCE = P × A
FORCE = (80 psi)(1,384 in^2)
FORCE = 110,779.2 lbs

FORCE = P × A
FORCE = (80 psi)(78.5 in^2)
FORCE = 6,280 lbs

$110{,}779.2 \text{ lb} \left| \frac{1 \text{ ton}}{2000 \text{ lb}} \right| = 55 \text{ tons}$

$6{,}280 \text{ lbs} \left| \frac{1 \text{ ton}}{2000 \text{ lb}} \right| = 3.14 \text{ tons}$

41. $15 \text{ feet} \left| \frac{0.433 \text{ psi}}{1 \text{ ft}} \right| = 6.5 \text{ psi}$

AREA = (0.785)(d^2)
= (0.785)(6 in)^2
= 28.26 in^2

FORCE = P · A
= (6.5 psi)(28.26 in^2)
= 183 lbs

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42. $\text{Velocity} = \frac{\text{Flow}}{\text{Area}}$

$42\text{ inches} \left| \frac{1\text{ ft}}{12\text{ inches}} \right| = 3.5\text{ ft}$

$\text{AREA} = 0.785 d^2$

$= (0.785)(3.5\text{ ft}^2)$

$= 9.62\text{ ft}^2$

$\text{Velocity} = \frac{35\text{ cfs}}{9.62\text{ sf}}$

$\text{Velocity} = 3.6\text{ f/s}$

43. $\text{Velocity} = \frac{\text{Flow}}{\text{Area}}$

$\text{Area} = l \cdot \text{depth}$

$\text{Area} = (2.4\text{ ft})(1.8\text{ ft})$

$\text{Area} = 4.32\text{ sf}$

$\frac{10\text{ ft}}{4.2\text{ sec}} = \frac{\text{Flow}}{4.32\text{ ft}^2}$

$2.38\text{ ft/s} = \frac{\text{Flow}}{4.32\text{ ft}^2}$

$10.28\text{ ft}^3/\text{s} = \text{Flow}$

44. FIND BOTH

$\text{AREA} = 0.785 d^2$

$= (0.785)(0.5\text{ ft}^2)$

$= 0.19625\text{ ft}^2$

$\text{AREA} = 0.785 d^2$

$= (0.785)(1\text{ ft})^2$

$= 0.785\text{ ft}^2$

$\frac{50\text{ gal}}{\text{min}} \left| \frac{1\text{ min}}{60\text{ sec}} \right| \frac{1\text{ ft}^3}{7.48\text{ gal}} \bigg| = 0.111\text{ cfs}$

$\text{Velocity} = \frac{Q}{A}$

$= \frac{0.111\text{ cfs}}{0.19625\text{ ft}^2}$

$= 0.57\text{ f/s}$

$\text{velocity} = \frac{Q}{A}$

$= \frac{0.111\text{ cfs}}{0.785\text{ ft}^2}$

$= 0.14\text{ f/s}$

velocity is 4 times greater in 6-inch pipe

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45. $\frac{4\text{ inches}}{} \bigg| \frac{1\text{ ft}}{12\text{ inches}} \bigg| = 0.33\text{ ft}$

$\text{Area} = 0.785d^2$
$= (0.785)(0.33\text{ ft})^2$
$= 0.0855\text{ sf}$

$\text{velocity} = \frac{Q}{A}$

$4.6\text{ fps} = \frac{Q}{0.0855\text{ sf}}$

$0.393\text{ cfs} = Q$

$\frac{0.393\text{ cf}}{\text{s}} \bigg| \frac{7.48\text{ gal}}{1\text{ cf}} \bigg| \frac{60\text{ sec}}{1\text{ min}} \bigg| = 176\frac{\text{gal}}{\text{min}}$

46. $\text{AREA} = l \cdot d$
$= (4\text{ ft})(2\text{ ft})$
$= 8\text{ ft}^2$

$\text{velocity} = \frac{Q}{A}$

$4.18\text{ fps} = \frac{Q}{8\text{ sf}}$

$33.44\text{ cfs} = Q$

$33.44\frac{\text{cf}}{\text{s}} \bigg| \frac{60\text{ sec}}{1\text{ min}} \bigg| \frac{7.48\text{ gal}}{1\text{ cf}} \bigg| = 15{,}008\frac{\text{gal}}{\text{min}}$

47. $\text{AREA} = 0.785d^2$
$= (0.785)(1\text{ ft})^2$
$= 0.785\text{ sf}$

$25\frac{\text{mg}}{\text{day}} \bigg| \frac{1000000\text{ gal}}{1\text{ mg}} \bigg| \frac{1\text{ cf}}{7.48\text{ gal}} \bigg| \frac{1\text{ day}}{1440\text{ min}} \bigg| \frac{1\text{ min}}{60\text{ sec}} \bigg| = 3.87\frac{\text{cf}}{\text{s}}$

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OR – look up the conversion 1mgd = 1.55 cfs
then

$$2.5\,\text{mgd} \left| \frac{1.55\,\text{cfs}}{1\,\text{mgd}} \right| = 3.875\ \text{cfs}$$

$$\text{velocity} = \frac{Q}{A}$$

$$\text{velocity} = \frac{3.875\,\text{cfs}}{1\,\text{sf}}$$

$$\text{velocity} = 3.875\ \text{ft/s}$$

48. $$HP = \frac{(\text{gpm})(\text{TDH, ft})}{3960}$$

$$HP = \frac{(120\,\text{gpm})(1200\,\text{ft})}{3960}$$

$$HP = 36.4$$

49. $$25\,\text{HP} \left| \frac{0.746\,\text{kW}}{1\,\text{HP}} \right| \frac{\$0.07}{1\,\text{kWH}} \left| \frac{8\,\text{hrs}}{1\,\text{day}} \right| \frac{7\,\text{days}}{1\,\text{week}} \right| = \$73.10$$

50. A) $$HP_{WATER} = \frac{(\text{gpm})(\text{TDH, ft})}{3960}$$

$$HP_{WATER} = \frac{(500\,\text{gpm})(50\,\text{ft})}{3960}$$

$$HP_{WATER} = 6.31$$

B) $$HP_{BRAKE} = \frac{(\text{gpm})(\text{TDH, ft})}{(3960)(E_p)}$$

$$= \frac{(500\,\text{gpm})(50\,\text{ft})}{(3960)(0.85)} = 7.42\ \text{HP}$$

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50. c) $HP_{MOTOR} = \frac{(gpm)(TDH, ft)}{(3960)(E_p)(E_m)}$

$HP_{MOTOR} = \frac{(500\ gpm)(50 ft)}{(3960)(0.85)(0.90)}$

$HP_{MOTOR} = 8.25$

D) WIRE TO WATER EFF. $= \frac{\text{WATER HP}}{\text{MOTOR HP}} \times 100$

$= \frac{6.31\ HP}{8.25\ HP} \times 100$

$= 76.5\%$

it also works to just multiply the efficiency terms

$E_p \times E_m \times 100$

$0.85 \times 0.90 \times 100$

76.5%

51. FIND THE VOLUME OF THE STROKE

6-inches = 0.5 ft

$V = 0.785 d^2 h$

$V = (0.785)(0.5 ft)^2 (0.5 ft)$

$V = 0.098\ cf/stroke$

$\frac{0.098\ cf}{stroke} \Big| \frac{60\ strokes}{1\ minute} \Big| \frac{7.48\ gal}{1\ cf} \Big| = 43.98$ or $44\ gal/min$

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52. Volume = l × w × h   8 inches = 0.67 ft

Volume = (6 ft)(6 ft)(0.67 ft)

Volume = 24.12 cf

$$\frac{24.12 \text{ cf}}{} \left| \frac{7.48 \text{ gal}}{1 \text{ cf}} \right| = 180.4 \text{ gallons}$$

$$\frac{180.4 \text{ gallons}}{5 \text{ minutes}} = 36 \text{ gpm}$$

53. $$HP_{BRAKE} = \frac{(\text{gpm})(\text{TDH, ft})}{(3960)(E_p)}$$

$$HP_{BRAKE} = \frac{(150 \text{ gpm})(75 \text{ feet})}{(3960)(0.90)}$$

$$HP_{BRAKE} = 3.16$$

54. $$3.16 \text{ HP} \left| \frac{0.746 \text{ kW}}{1 \text{ HP}} \right| \frac{\$0.08}{1 \text{ kWh}} \left| \frac{12 \text{ hrs}}{1 \text{ day}} \right| \frac{365 \text{ d}}{1 \text{ year}} \right| = \$826.02$$

55. $$4 \text{ inches} \left| \frac{1 \text{ ft}}{12 \text{ inches}} \right| = 0.33 \text{ ft}$$

$$8 \text{ inches} \left| \frac{1 \text{ ft}}{12 \text{ inches}} \right| = 0.67 \text{ ft}$$

$$V = 0.785 d^2 h$$

$$V = (0.785)(0.33 \text{ ft})^2(0.67 \text{ ft})$$

$$V = 0.0573 \text{ cf/stroke}$$

$$\frac{0.0573 \text{ cf}}{\text{stroke}} \left| \frac{16 \text{ strokes}}{1 \text{ min}} \right| \frac{7.48 \text{ gal}}{1 \text{ cf}} \right| = 6.9 \text{ gal/min}$$

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56. $\frac{178 \text{ mL}}{\text{min}} \Big| \frac{1 \text{ L}}{1000 \text{ mL}} \Big| \frac{1 \text{ gal}}{3.785 \text{ L}} \Big| \frac{1440 \text{ min}}{1 \text{ day}} \Big| = 67.7 \frac{\text{gal}}{\text{day}}$

57. $\frac{300 \text{ gal}}{\text{min}} \Big| \frac{1440 \text{min}}{1 \text{ day}} \Big| \frac{1 \text{ MG}}{1000000 \text{ gal}} \Big| = 0.432 \frac{\text{mg}}{\text{d}}$

Feed Rate = (Dose, mg/L)(Capacity, mgd)(8.34 lbs/gal)
Feed Rate = (2.0 mg/L)(0.432 mgd)(8.34 lbs/gal)
Feed Rate = 7.2 pounds/day

58. DOSE = DEMAND + RESIDUAL
DOSE = 1.2 mg/L + 2.0 mg/L
DOSE = 3.2 mg/L

$\text{FEED RATE} = \frac{(\text{DOSE, mg/L})(\text{Capacity, mgd})(8.34 \text{ lbs/gal})}{(\text{Purity})}$

$\text{FEED RATE, ppd} = \frac{(3.2 \text{ mg/L})(5.6 \text{ mgd})(8.34 \text{ lbs/gal})}{0.65}$

FEED RATE, ppd = 230

59. $\frac{5 \text{ mg}}{\text{d}} \Big| \frac{1000000 \text{ gal}}{1 \text{ mg}} \Big| \frac{1 \text{ d}}{1440 \text{ min}} \Big| = 3472 \frac{\text{gal}}{\text{min}}$

$\text{FEED RATE, fluoride sat, gpm} = \frac{(\text{Plant Capacity, gpm})(\text{Dose, mg/L})}{18{,}000 \text{ mg/L}}$

$\text{FEED RATE, gpm} = \frac{(3472 \text{ gpm})(4 \text{ mg/L})}{18{,}000 \text{ mg/L}}$

FEED RATE, gpm = 0.77

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60. $ppd = (mg/L)(Q, mgd)(8.34\ lb/gal)$

$ppd = (2.6\ mg/L)(5\ mgd)(8.34\ lb/gal)$

$ppd = 108.42$

$108.42\ ppd\ Cl_2 \left| \frac{\$0.21}{1\ lb\ Cl_2} \right| = \$22.77$

61. how much does one gallon weigh?

8.34 lbs

so...

$(8.34\ lbs)(5.25\%) = 0.437\ lbs\ Cl_2$

62. $18\ inches \left| \frac{1\ ft}{12\ inches} \right| = 1.5\ ft.$

Volume of Well = $(0.785)(d^2)(h)$

Volume of Well = $(0.785)(1.5\ ft)^2(80\ ft)$

Volume of Well = 141.3 cf

$141.3\ cf \left| \frac{7.48\ gal}{1\ cf} \right| \frac{1\ MG}{1000000\ gal} \right| = 0.001056924\ MG$

$$\text{FEED RATE, lbs/day} = \frac{(\text{DOSE}, mg/L)(\text{Capacity}, mg)(8.34\ lbs/gal)}{\text{PURITY}}$$

$$\text{FEED RATE, lbs/d} = \frac{(115\ mg/L)(0.001056924\ mg)(8.34\ lbs/gal)}{0.0525}$$

FEED RATE, lbs/d = 19.31

BUT, THEY ASKED FOR GALLONS OF BLEACH

$19.31\ \frac{lbs}{day}\ bleach \left| \frac{1\ gallon}{8.34\ lbs} \right| = 2.3\ gallons$

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63. $\frac{600 \text{ gal}}{\text{min}} \Big| \frac{1 \text{ MG}}{1000000 \text{ gal}} \Big| \frac{1440 \text{ min}}{1 \text{ day}} \Big| = 0.864 \frac{\text{mg}}{\text{d}}$

IRON, lbs/day = (mg/L X Q, mgd X 8.34 lbs/gal)
IRON, lbs/day = (0.06 mg/L X 0.864 mgd X 8.34 lbs/gal)
IRON, lbs/day = 0.432

$\frac{0.432 \text{ lbs IRON}}{\text{day}} \Big| \frac{365 \text{ days}}{1 \text{ year}} \Big| = 157.7 \text{ lbs/year}$

MANGANESE, lbs/day = (mg/L X Q, mgd X 8.34 lbs/gal)
MANGANESE, lbs/day = (0.30 mg/L X 0.864 mgd X 8.34 lbs/gal)
MANGANESE, lbs/day = 2.16

$\frac{2.16 \text{ lbs MANGANESE}}{\text{DAY}} \Big| \frac{365 \text{ days}}{1 \text{ year}} \Big| = 788.4 \text{ lbs/year}$

64. $\text{FEED RATE, lbs/day} = \frac{(\text{DOSE, mg/L}) \times (\text{capacity, mgd}) \times (8.34 \text{ lb/gal})}{\text{PURITY}}$

$\text{FEED RATE} = \frac{(0.6 \text{ mg/L}) \times (30 \text{ mg}) \times (8.34 \text{ lb/gal})}{0.25}$

FEED RATE, lbs/day = 600.48

65. $\text{CHEMICAL FEED PUMP SETTING, mL/min} = \frac{(\text{Flow, mgd}) \times (\text{Dose, mg/L}) \times (3.785 \text{ L/gal}) \times (1{,}000{,}000 \text{ gal/mg})}{(\text{Liquid, mg/L}) \times (24 \text{ hr/d}) \times (60 \text{ min/hr})}$

$\text{CHEMICAL FEED PUMP SETTING, mL/min} = \frac{(3.2 \text{ mgd}) \times (9 \text{ mg/L}) \times (3.785 \text{ L/gal}) (1{,}000{,}000 \text{ gal/mg})}{(642.3 \text{ mg/L}) \times (24 \text{ hr/d}) \times (60 \text{ min/hr})}$

FEED PUMP SETTING, mL/min = 117.9

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#65 REPRISE – you can also use the $C_1V_1 = C_2V_2$ formula to solve this problem

$$\frac{3.2\ MG}{day} \left| \frac{1000000\ gal}{1\ MG} \right| \frac{3.785\ L}{1\ gal} \left| \frac{1\ day}{1440\ min} \right| = 8411.11\ \frac{mL}{min}$$

$$C_1V_1 = C_2V_2$$
$$(642.3\ mg/L)(V_1) = (9\ mg/L)(8411.11\ mL/min)$$
$$(642.3\ mg/L)(V_1) = 75699.99$$
$$V_1 = 117.9\ mL/min$$

66. FEED RATE, gpm Fluoride Saturator = $\frac{(\text{Plant Capacity, gpm})(\text{Doseage, mg/L})}{18{,}000\ mg/L}$

$$\text{FEED RATE, gpm} = \frac{(400\ gpm)(3 - 1.8\ mg/L)}{18{,}000\ mg/L}$$

$$\text{FEED RATE, gpm} = \frac{(400\ gpm)(1.2\ mg/L)}{18{,}000\ mg/L}$$

$$\text{FEED RATE, gpm} = 0.0267$$

67. Alum consumes 0.5 mg of alkalinity per mg of Alum

$$15\ mg/L\ Alum \left| \frac{0.5\ Alkalinity}{1\ Alum} \right| = 7.5\ mg/L\ \text{Alkalinity used}$$

$$\begin{array}{r} 50\ mg/L \\ -\ 7.5\ mg/L \\ \hline 42.5\ mg/L \end{array}$$ Alkalinity remaining

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68. $AREA = l \cdot w$

$AREA = (12\,ft)(12\,ft)$

$AREA = 144\,sf$ $\qquad (144\,sf)(3\text{ filters}) = 432\,sf$

$$\frac{9.5\,mg}{d} \left| \frac{1\,d}{1440\,min} \right| \frac{1000000\,gal}{1\,mg} \bigg| = 6597 \frac{gal}{min}$$

$$\text{HYDRAULIC LOADING RATE} = \frac{\text{FLOW, gpm}}{\text{Area, sf}}$$

$$\text{HYDRAULIC LOADING RATE} = \frac{6597\,gpm}{432\,sf}$$

$$HLR = 15\,gpm/sf$$

69. $Area = l \cdot w$

$Area = (10\,ft)(15\,ft)$

$Area = 150\,sf$

$$\text{FILTER BACKWASH RISE RATE, in/min} = \frac{(\text{BACKWASH RATE, gpm/sf})(12\,in/ft)}{(7.48\,gal/cf)}$$

$$\text{RISE RATE, in/min} = \frac{(8\,gpm/sf)(12\,in/ft)}{(7.48\,gal/cf)}$$

$$\text{RISE RATE, in/min} = 12.83$$

OR

$$\frac{8\,gal}{min \cdot sf} \left| \frac{1\,cf}{7.48\,gal} \right| \frac{12\,inches}{1\,ft} \bigg| = 12.83 \frac{inches}{min \cdot sf}$$

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70. $\text{RISE RATE, in/min} = \dfrac{(\text{BACKWASH RATE, gpm/sf})(12 \text{ inches/ft})}{7.48 \text{ gal/cf}}$

$$30 \text{ in/min} = \frac{(\text{BACKWASH, gpm/sf})(12 \text{ inches/ft})}{7.48 \text{ gal/cf}}$$

$$224.4 = (\text{BACKWASH, gpm/sf})(12 \text{ inches/ft})$$

$$18.7 \frac{\text{gpm}}{\text{sf}} = \text{BACKWASH, gpm/sf}$$

71. Pretend as if all flow is going to one filter

$$\frac{5.0 \text{ mg}}{\text{day}} \left| \frac{1000000 \text{ gal}}{1 \text{ mg}} \right| \frac{1 \text{ day}}{1440 \text{ min}} = 3472 \frac{\text{gal}}{\text{min}}$$

$\text{AREA} = l \cdot w$
$\text{AREA} = (12 \text{ ft})(20 \text{ ft})$
$\text{AREA} = 240 \text{ sf}$

$\text{HLR} = \dfrac{\text{gpm}}{\text{sf}}$

$\text{HLR} = \dfrac{3472 \text{ gpm}}{240 \text{ sf}}$

$\text{HLR} = 14.5 \text{ gpm/sf}$ ∴ 1 filter on-line

72. $\text{FILTER YIELD, lbs/hr/sf} = \dfrac{(\text{solids loading, lbs/d} \times \%\ \text{Recovery})}{(\text{Filter Operation, hr/day})(\text{Area, sf})}$

$\text{FILTER YIELD, lbs/hr/sf} = \dfrac{(200\ \text{lbs/d} \times 0.95)}{(12\ \text{hrs/d} \times 40\ \text{sf})}$

$\text{FILTER YIELD, lbs/hr/sf} = 0.4$

73. $\text{ppd} = (\text{mg/L} \times Q, \text{mgd} \times 8.34\ \text{lb/gal})$

$\text{ppd} = (120\ \text{mg/L} \times 2.0\ \text{mgd} \times 8.34\ \text{lb/gal})$

$\text{ppd} = 2001.6$

$\text{Area} = l \cdot w$

$\text{Area} = (20\ \text{ft} \times 20\ \text{ft})$

$\text{Area} = 400\ \text{sf}$ $\qquad (400\ \text{sf} \times 2\ \text{filters}) = 800\ \text{sf}$

$\text{FILTER YIELD, lbs/hr/sf} = \dfrac{(\text{solids, lb/d} \times \%\ \text{Recovery})}{(\text{operation, hr/d})(\text{Area, sf})}$

$\text{FILTER YIELD, lbs/hr/sf} = \dfrac{(2001.6\ \text{lbs/d} \times 0.99)}{(22\ \text{hrs/d} \times 400\ \text{sf})}$

$\text{FILTER YIELD, lbs/hr/sf} = 0.22518$

$0.22518\ \dfrac{\text{lbs}}{\text{hr}\cdot\text{sf}} \Big| \dfrac{400\ \text{sf}}{} \Big| \dfrac{22\ \text{hrs}}{1\ \text{day}} \Big| = 1981.58\ \text{lbs/day}$

or

just take lbs $(2001.6 \times 0.99) = 1981.58\ \text{lbs/day}$
(lbs/day) (capture)

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74. $\text{WEIR OVERFLOW RATE} = \dfrac{\text{FLOW, gpd}}{\text{WEIR LENGTH, ft}}$

$\text{WEIR OVERFLOW RATE} = \dfrac{2{,}000{,}000\text{ gpd}}{80\text{ ft}}$

$\text{WEIR OVERFLOW RATE} = 25{,}000\text{ gpd/ft}$

75. $C_1V_1 = C_2V_2$

$(1{,}000\text{ mg/L})(V_1) = (50\text{ mg/L})(250\text{ mL})$

$(1{,}000\text{ mg/L})(V_1) = 12500$

$V_1 = 12.5\text{ mL}$

76. $C_1V_1 = C_2V_2$

$(10{,}000\text{ mg/L})(150\text{ mL}) = (C_2)(120\text{ mL})$

$1500000 = (C_2)(120\text{ mL})$

$12{,}500\text{ mg/L} = C_2$

77. $\dfrac{7.74\text{ cf}}{\text{s}} \Big| \dfrac{7.48\text{ gal}}{1\text{ cf}} \Big| \dfrac{60\text{ sec}}{1\text{ min}} \Big| = 3473.712\ \dfrac{\text{gal}}{\text{min}}$

$C_1V_1 = C_2V_2$

$(5{,}000\text{ mg/L})(V_1) = (25\text{ mg/L})(3473.712\text{ gpm})$

$(5{,}000\text{ mg/L})(V_1) = 86842.8$

$V_1 = 17.4\text{ gal/min}$

78. $C_1V_1 = C_2V_2$

$(C_1)(4.3\text{ gpm}) = (25\text{ ppm})(800\text{ gpm})$

$(C_1)(4.3\text{ gpm}) = 20{,}000$

$C_1 = 4651\text{ ppm}$

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79. $C_1V_1 + C_2V_2 = C_3V_3$

$(0.5\text{ mg/L})(600\text{ gpm}) + (12.5\text{ mg/L})(350\text{ gpm}) = C_3(600 + 350\text{ gpm})$

$300 + 4375 = C_3(950)$

$4675 = C_3(950)$

$4.92\text{ mg/L} = C_3$

80. $C_1V_1 = C_2V_2$

$(8\%)(V_1) = (0.6\%)(150\text{ gallons})$

$(8\%)(V_1) = 90$

$V_1 = 11.25\text{ gallons}$

81. units don't agree, so convert

$$\frac{500\text{ gal}}{\text{min}} \left| \frac{1\text{ MG}}{1000000\text{ gal}} \right| \frac{1440\text{ min}}{1\text{ day}} = 0.72\text{ MGD}$$

$C_1V_1 + C_2V_2 = C_3V_3$

$(1500\text{ mg/L})(0.72\text{ mgd}) + (250\text{ mg/L})(6\text{ mgd}) = C_3(0.72 + 6\text{ mgd})$

$1080 + 1500 = C_3(6.72)$

$2580 = C_3(6.72)$

$383.9\text{ mg/L} = C_3$

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82. if $V_3 = V_1 + V_2$ complicated
then $V_1 = V_3 - V_2$ algebra

$C_1V_1 + C_2V_2 = C_3V_3$

$(22\text{ mg/L})(400 - V_2) + (3\text{ mg/L})(V_2) = (8\text{ mg/L})(400\text{ gpm})$

$8800 - (22\text{ mg/L})(V_2) + (3\text{ mg/L})(V_2) = 3200$

$8800 - (19\text{ mg/L})(V_2) = 3200$

$-(19\text{ mg/L})(V_2) = 3200 - 8800$

$-(19\text{ mg/L})(V_2) = -5600$

$(19\text{ mg/L})(V_2) = 5600$

$V_2 = 294.7\text{ gpm}$

Well 1 @ 22 mg/L Arsenic

  400
− 294.7 gpm
  105.3 gpm