MISCELLANEOUS FORMULAS

Leakage Formula:

$$L = \frac{S \times D \times \sqrt{P}}{148{,}000}$$

Where:
- L = allowable leakage (gallons per hour)
- S = Length of pipe tested (feet)
- D = pipe diameter (inches)
- $\sqrt{P}$ = square root of the pressure (P expressed in psi)

Dilution Equation $C_1V_1 = C_2V_2$

Chlorine Dosage = Demand + Residual

PPM $= \frac{\text{lbs. of chemical}}{\text{Million lbs. of } H_2O}$

Pumping Rate, GPM $= \frac{\text{Volume, gal}}{\text{Time, min}}$

Detention Time $= \frac{\text{Volume}}{\text{Flow}}$

Power Output, horsepower $= \frac{\text{(Power Input, kilowatts)(Efficiency, \%)}}{\text{(0.746 kilowatt/horsepower)(100\%)}}$

C*T = Chlorine Residual (mg/L) x time(minutes)

Velocity $= \frac{\text{Distance (Ft)}}{\text{Time (Sec)}}$

Bernoulli's Equation

$$\frac{P_1}{w} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2 + H_L$$

Filtration Rate (gpm/ft²) $= \frac{\text{Flow (gpm)}}{\text{Surface Area (ft}^2\text{)}}$

Langlier Index = pH - pH_s

Circumference = π x diameter or 2 x π x r

Hardness, grains/gallon $= \frac{\text{(Hardness, mg/L)(1 grain/gallon)}}{\text{17.1 mg/l}}$

Total Hardness, mg/L as $CaCO_3$ = Calcium Hardness, mg/L as $CaCO_3$ + Magnesium Hardness, mg/L as $CaCO_3$

Conversion Factors	
1 ft³	= 7.48 gallons
1 gallon of H_2O	= 8.34 lbs
1 mg/L	= 1 ppm
1 mile	= 5280 feet
1 acre	= 43560 ft²
1 psi	= 2.31 feet of head
1 horsepower	= 0.746 kilowatts
1 ppb	= 1ug/L
1 gallon	= 8 pints

Conversion Factors	
1feet of head	= 0.433 psi
1 ft³ of water	= 62.4 lbs
1 inch	= 2.54 centimeters
1 grain per gallon	= 17.12 mg/L
1 horsepower	= 33,000 ft lbs/min
1 yard³	= 27 ft³
1 kilogram	= 2.2 lbs
1 lbs	= 454 grams
1 kilograms	= 1000 grams

Temperature	
Fahrenheit (°F)	= (1.8x°C) + 32
Celsius (°C)	= 0.56 x (°F-32)

Flow and Velocity	
Q	= V x A
Q	= Flow
V	= Velocity
A	= Area

Area	
Rectangle	= length x width
Circle	= 0.785 x Diameter²
Circle	$= \pi \; x \; radius^2$
Triangle	= 0.5 x base x height
Sphere	$= 4 \; x \; \pi \; x \; radius^2$
Cylinder	= (2 x π x r x h) + (2 x π x r²)

Volumes	
Cone: V	= 1/3 x 0.785 x D² x H
Cone: V	= 1/3 x π x R² x H
Cylinder: V	= π x R² x H
Cylinder: V	= 0.785 x D² x H
Rectangular Prism: V	= L x W x H
Pyramid: V	= L x W x (1/3)H
Sphere: V	= 4/3(πr³)

WATER-BRAKE-MOTOR HORSEPOWER

WHP $= \frac{\text{GPM x Total Head (ft)}}{3960}$

BHP $= \frac{\text{GPM x Total Head (ft)}}{3960 \text{ x } E_p}$

MHP $= \frac{\text{GPM x Total Head (ft)}}{3960 \text{ x } E_p \text{ x } E_m}$

E_p = Pump Efficiency (%)
E_m = Motor Efficiency (%)

L = Length
B = Base
W = Width
H = Height

V = Volume
R = Radius
D = Diameter
π = 3.14

Total Dynamic Head, ft = Static Head, ft + Discharge Head, ft + Friction Losses, ft

SESSION 1

BASIC MATH REVIEW

A water plant operator must have a working knowledge of the algebraic operations of ratios, proportions and "solving for the unknown".

RATIOS AND PROPORTIONS

A ratio is the quotient of two numbers. The ratio of 1 to 2 is written as 1/2 or 1:2. A proportion is a relationship where two or more ratios are said to be equal. For example,

1/2 = 4/8 = 3/6 or $\frac{1}{2} = \frac{4}{8} = \frac{3}{6}$

The principles of ratios and proportions can be used to "solve for the unknown"

A common practice used in algebra is to use letters to represent unknown numerical quantities. Frequently, the letter "X" is used to represent the unknown. For example, if I save $25.00 from my paycheck every week for a year, how much will I save?

$$x \text{ dollars} = ?$$

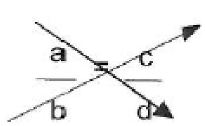
$$\frac{52 \text{ weeks}}{\text{year}} \times \frac{\$25}{\text{week}} = x = \$1{,}300.00$$

To use ratios and proportions to solve for an unknown quantity, the following method is used. Say that

$$\frac{a}{b} = \frac{c}{d}$$

Verbally this says that **a** is to **b** as **c** is to **d**. When solving problems involving proportions, we use cross multiplication. Therefore, from the proportion

we get a x d = b x c



EXAMPLE:

To solve for the unknown quantity, x

$$\frac{x}{5} = \frac{8}{2}$$

First, cross multiply

$$2 \times x = 5 \times 8 = 40 \quad or \quad 2x = 40$$

Now divide both sides of the equality by 2 to isolate the unknown quantity x

$$\frac{2x}{2} = \frac{40}{2} = 20 \qquad or \qquad x = 20$$

Sample Problems: Find x

$\frac{16}{2} = \frac{x}{2}$ X = ____________________

$\frac{9}{3} = \frac{3}{x}$ X =____________________

$\frac{15}{5} = \frac{6}{x}$ X = ____________________

The very basic idea of solving for the unknown, as demonstrated above, can be used to determine unknown quantities in more difficult problems. Some of these problems will be discussed later in this course.

PERCENTAGE

Percent means parts per 100 parts. Percent expresses a fraction which has a denominator equal to 100. Percentages are related to common fractions and decimal fractions.

Percentages	Common Fraction	Decimal Fraction
6	6/100 or $\frac{6}{100}$	0.06
12.5	12.5/100 or 125/1000	0.125
15	15/100	0.15
25	25/100	0.25
79.1	79.1/100 or 791/1000	0.791

By comparing the percentages column to the decimal fraction column, we see the relationship between them. If we move the decimal point in a percentage two places to the left, we have a decimal; if we move the decimal point in a decimal fraction two places to the right, we have a percentage. This is the same as dividing by or multiplying by 100.

Often we are required to determine what percent one number is of another number. To do this, we convert the percentage to a decimal and multiply as appropriate.

Example: What is 25% of 90?

Solution: First, convert 25% to its decimal equivalent --- 0.25. Since we want "percent of" we multiply the decimal equivalent by the number we want to take the percentage of.

25% of 90 = ?

0.25 x 90 = 22.5 or $90 \times \frac{25}{100} = 22.5$

Rounding off, we get 23 = 25% of 90. Think of "percent of' as meaning the same as "multiply by."

Example: What is 32% of 612?

Solution: Since 32% = 0.32, we get;

0.32 x 612 = 195.84 or $612 \times \frac{32}{100} = 195.84$

Rounding off, we get 196 = 32% of 612.

Example: A 500 gallon tank contains 320 gallons. What percent of the tank is full?

Solution: Remember that a percent means parts per 100 parts. In this example, we need to express the problem as a fractional or decimal relationship and then convert the fraction or decimal to a percentage. First, think of the problem as a "parts per parts" problem. Relate the number of gallons in the tank to the total number of gallons available in the tank.

$$320 \textit{ gallons in a } 500 \textit{ gallon} \text{ tank } \textit{is the same as;}$$
$$\frac{320 \textit{ gallons}}{500 \textit{ gallons}} \textit{ or } 320 \textit{ gal} \div 500 \textit{ gal}$$
$$320 \textit{ gal} \div 500 \textit{ gal} = 0.64$$
$$\textit{converting the decimal } 0.64 \textit{ to a percent gives us } 64\%$$

Example: City Hall conducted a survey of the water customers. 2275 out of 3500 people want a new iron removal plant. What percent of those surveyed want a new iron removal plant?

Solution: 2275 out of 3500 means 2275 ÷ 3500, dividing we get 0.65, converting the decimal fraction to a percent yields 65%. This means 65% of the customers surveyed were in favor of the new plant.

SAMPLE PROBLEMS

1. Write the decimal equivalent of the following percentages.
   (a) 49% Answer ________
   (b) 3% Answer ________
   (c) 151% Answer ________

2. Express the following decimals in percentages.
   (a) 0.1 Answer ________
   (b) 7.52 Answer ________
   (c) 0.19 Answer ________

3. An elevated tank is half full. What percent is this?

4. A chemical solution tank with a 50-gal capacity is to be filled to the 90% mark. How many gallons are required to do this?

5. A water treatment plant with a capacity of 550,000 gal/day is operating at 75% capacity. How much water is this plant processing?

Percentage computations are frequently made by utility personnel when calculating chlorine dosages and other chemical feed rates, pump and motor efficiencies and in other instances.

UNITS AND CONVERSIONS

In order to attach any meaning to numbers used to indicate lengths, widths, volumes, areas, and the like, we must assign units to these numbers. The number "12" has considerably different meaning if it is assigned different units; such as acres, gallons, grams or inches. Quite often, measurements must be converted from one set of units to another.

1 foot = 12 inches

1 yard = 3 feet = 36 inches

When adding, subtracting, multiplying or dividing figures, they must be in the same units. If they are not, they must be converted to a common unit. Values for conversion factors are considered to be exact values.

Example:

$$8 \; miles + 4 \; feet + 50 \; yards = ?$$

If all these are converted to feet, then:

$$\begin{aligned} 8 \; miles &= 8 \; miles \times \frac{5280 \; feet}{mile} &= 42{,}240 \; feet \\ 4 \; feet &= &= 4 \; feet \\ 50 \; yards &= 50 \; yards \times \frac{3 \; feet}{yard} &= 150 \; feet \\ & & \overline{42{,}394 \; feet} \end{aligned}$$

EXAMPLE:

$$5\ yards + 2\ feet + 10\ inches = ?$$

Convert these all to feet.

$$5\ yards = 5\ yards \times \frac{3\ feet}{yard} = 15\ feet$$

$$2\ feet = \quad = 2\ feet$$

$$10\ inches = 10\ inches \times \frac{1\ foot}{12\ inches} = \underline{0.83\ feet}$$

$$17.83\ feet$$

To convert figures from one unit to another, use ofa conversion factor is necessary.

Table 1 lists some conversion factors used to convert figures to common units.

TABLE 1

Multiply	By	To Obtain
Acres (a)	43,560	Square Feet (ft² or sq.ft .)
Cubic Feet (ft³ or cu.ft.)	7.48	Gallons (gal)
Cubic Feet (ft³ or cu.ft.)	62.4	Pounds of water (lbs)
Cubic Feet/Second (cfs)	0.646	Million Gallons/Day (MGD)
Feet of Water (ft)	0.433	Pounds/Square Inch (psi)
Gallons (gal)	0.1337	Cubic Feet (ft³ or cu.ft.)
Gallons of water (gal)	8.34	Pounds of Water (lbs)
Grains/U.S. Gallons (gr/gal)	17.118	Parts per Million (ppm)
Grams	0.002205	Pounds (lbs)
Grams/Liter (g/l)	1,000	Parts per Million (ppm)
Inches (in or")	0.0833	Feet (ft or ')
Inches of water (in or")	0.03513	Pounds/Square Inch (psi)
Parts per Million (ppm)	0.0584	Grains/U.S. Gallon (gr/gal)
Pounds (lbs)	453.6	Grams (g)
Pounds of water (lbs)	0.01602	Cubic Feet (ft³ or cu.ft.)
Pounds of water (lbs)	0.1198	Gallons (gal)
Pounds/Square Inch (psi)	2.31	Feet of water (ft)
Million Gallons/Day (MGD)	1.55	Cubic Feet/Second (cfs)

To use this chart, you take a value in a unit on the left and multiply it by the "conversion factor" in the middle column to obtain a value in the corresponding units on the right. The following example demonstrates this.

Question:

A storage tank holds 2,000 cubic feet of water.

(a) How many gallons of water will it hold?

(b) How much does this amount of water weigh?

Solution:

To work this problem, you should refer to Table 1.

(a) From the chart, if we multiply 2,000 cubic feet by 7.48, we will obtain the number of gallons which this is equivalent to.

$$2{,}000\ ft^3 \times 7.48 = 14{,}960\ gallons\ or\ approximately\ 15{,}000\ gallons$$

This works because 7.48 is the "conversion factor" used to convert from cubic feet to gallons. This conversion factor has units and it should be used with the units so mistakes are not made.

$$7.48\ gallons\ per\ cubic\ foot = 7.48\ \frac{gal}{ft^3}$$

When working with conversion factors and units, remember that units above the fraction bar cancel out similar units below the fraction bar.
For our example

$$2{,}000\ ft^3 \times 7.48\ \frac{gal}{ft^3} = 14{,}960\ gallons\ or\ 15{,}000\ gallons$$

For Part (b) of this question, we must convert from gallons to pounds.

(a) The conversion factor used to convert gallons of water to pounds of water is 8.34 pounds per gallon or, $8.34\frac{lb}{gal}$ therefore,

$$15{,}000\ gal \times 8.34\ \frac{lb}{gal} = 125{,}100\ lbs\ of\ water\ or\ 125{,}000\ lbs\ of\ water$$

In this case, gallons are in both the numerator and denominator and can therefore be canceled.

The two conversion factors discussed above are so important to mathematical computations involving water treatment that they simply must be memorized.

Memorize:

$$7.48\,\frac{gal}{ft^3}\ and\ 8.34\,\frac{lb}{gal}$$

From these two conversion factors, we can develop another important factor

$$7.48\,\frac{gal}{ft^3} \times 8.34\,\frac{lb}{gal} = 62.4\,\frac{lbs}{ft^3} = 62.4\ lbs\ per\ ft^3$$

This value is the density of water.

CANCELING UNITS

Sometimes, simply knowing what units you have and what units you need determines which conversion factor(s) you should use. For example, if we have, "days", and want to go to "seconds", it is best to write out the unit conversions first, then supply the numerical conversion factors later.

$$days \times \frac{hrs}{days} \times \frac{\min}{hr} \times \frac{\sec}{\min} = \text{seconds}$$

This gives seconds, now put in the numerical conversion factor values.

$$days \times \frac{24\ hrs}{days} \times \frac{60\ \min}{hr} \times \frac{60\ \sec}{\min} = 86{,}400\ \text{seconds}$$

Occasionally, we have to divide a unit value by a conversion factor.

$$\frac{87{,}120\ ft^2}{43{,}560\ ft^2/acre}$$

The conversion factor is like a fraction, it has a value and associated unit both above and below the fraction bar. Hence, we can invert the conversion factor and multiply to obtain our answer with units canceled.

$$87{,}120\ ft^2 \times \frac{acre}{43{,}560\ ft^2} = 2\ acres$$

SAMPLE PROBLEMS:

6. Five cubic feet of water weigh how many pounds?

   Answer _________________

7. Thirteen gallons of water occupy how many cubic feet?

   Answer _________________

8. A tank has a capacity of 90,000 cubic feet. What is the gallons capacity of the tank?

   Answer _________________

CALCULATIONS OF AREAS AND VOLUMES

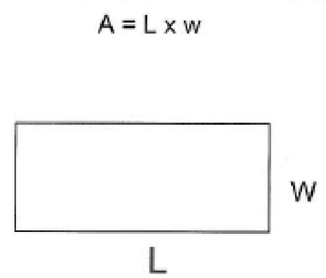
The ability to correctly calculate areas and volumes is a valuable tool for a water treatment operator. Area can be thought of as a measurement of the surface of a figure having only two dimensions: length and width. Units are square inches (sq.in. or in^2), square feet (sq.ft. or ft^2), square miles and so forth depending on the unit of length used.

A figure in three dimensions, enclosed on all sides by three or more plane surfaces is termed a solid figure and its size or occupied space is expressed in terms of its volume.

Some of the simpler shapes commonly encountered, their areas, (A) and volumes, (V) are given below.

The **RECTANGLE**, a four sided figure having four right (90°) angles.

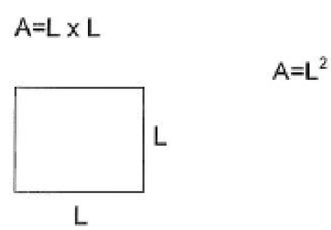
AREA= length (L) times width (w)



A **SQUARE**, is a special case of the rectangle in which all sides are of equal length.

L= w

AREA = length (L) times width (w)



A **CIRCLE**, is a closed curve which all points on the curve are equally distant from a fixed point called the center. The distance from the center to the circle is the radius (r).

The area is given as pi (π = 3.14) times the radius squared.

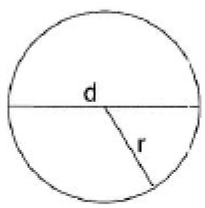
AREA = pi times radius times radius = (3.14) x (r) x (r)

$A = 3.14 \times r^2$ or $A = \pi r^2$

or

$A = 3.14 \times \frac{d^2}{4}$ since the diameter is equal to 2 times the radius or

radius = ½ diameter.



$A = 3.14 \times r^2 = 3.14 \times \left(\frac{1}{2}d\right)^2 = 3.14 \times \frac{d^2}{4}$ and

$\frac{3.14}{4} = 0.785$

$\underline{A = 0.785 \times d^2}$

$C = 2(3.14)\, r = (3.14)\, d$

The **CIRCUMFERENCE** (C) or length or the line forming the closed curve is given by,

CIRCUMFERENCE= pi times 2 times radius.

What is the area of a rectangular room measuring 32 ft in length and 42 ft wide?

The standard isolation area of a municipal well is 200 feet in all directions from the well. How many square feet is this?

What is the circumference of the well isolation area circle noted in the problem above?

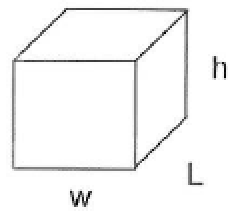
CUBE

VOLUME = area of base (L x w) times height (h)

$V = L \times w \times h$

$L = w = h$

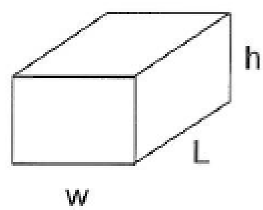
$V = L^3$



RECTANGULAR PRISM

VOLUME = area of base (w x L) times height (h)

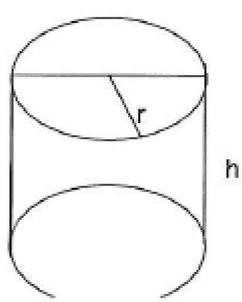
$V = w \times L \times h$.



CYLINDER

VOLUME = area of base ($3.14 \times r^2$) times height (h)

$V = 3.14 \times r^2 \times h = 0.785 \times d^2h$



The following sample problems will test your understanding of the calculation of area and volume concepts.

9. Determine the volume of a chemical feed solution tank if the tank has a 36-inch diameter and is 4 feet high.

ANSWER ______________________________

10. How many gallons of water would the tank hold?

ANSWER ______________________________

11. What is the total weight of this amount of water?

ANSWER ______________________________

12. What volume in cubic feet does 1000 feet of 12-inch main have?

ANSWER ______________________________

13. How many gallons would a rectangular basin measuring 30 feet by 16 feet by 10 feet, hold?

ANSWER ______________________________

CONCENTRATION EXPRESSION

Concentration for chlorine or other elements or compounds in water are commonly expressed in terms of parts per million (ppm) or milligrams per liter (mg/l). Basically, these terms are the same and are interchangeable. A part per million (ppm) can be defined as a part per million parts or as a pound per million pounds. When the term is written as a formula, all the units cancel out and a unit less fraction is left.

$$\frac{one\ part}{one\ million\ parts} = \frac{one\ pound}{one\ million\ pounds} = \frac{one}{one\ million}$$

When calculating the concentration of a chemical in water, the weight of the chemical is placed on the top of the concentration formula and the weight of water, expressed in millions of units, is put on the bottom of the formula.

Example: $\frac{pounds\ of\ chemical}{million\ pounds\ of\ water}$

The concentration formula can be used with any chemical at any concentration. Listed below are two formulas which should be remembered:

$$ppm = \frac{pounds\ of\ pure\ chemical}{million\ pounds\ of\ water}$$

$$mg/l = \frac{milligrams\ of\ pure\ chemical}{liters\ of\ water}$$

EXAMPLE: One pound of chlorine in 5,000 pounds of water equals what concentration of mg/l?

$$\frac{5{,}000\ lbs}{1{,}000{,}000} = 0.005\ million\ lbs\ (M\ lbs)$$

$$mg/l = ppm = \frac{lbs}{M\ lbs} = \frac{1\ lb}{0.005\ M\ lbs} = 200\ ppm = 200\ mg/l$$

Another way to write the ppm equation is

$$pounds\ of\ pure\ chemical = ppm \times million\ pounds\ of\ water$$

This form of the equation may help you solve other types of problems.

SAMPLE PROBLEMS:

14. 5 pounds of chlorine in 7 million pounds of water equals what concentration in ppm?

15. 5 pounds of chlorine in 200,000 pounds of water equals what concentration in ppm?

16. 6 pounds of chlorine in 15,000 gallons equals what concentration in ppm?

17. Theoretically, how many pounds of pure chlorine must be added to 900,000 gallons of water to produce a residual of 2.0 ppm?

In most operations, 100% available chemical is not used (gas chlorine is the exception). Frequently, some other concentration of available chlorine is used.

These concentrations are expressed in terms of "percent available chlorine." Typical percents include; 5.25%, 10%, and 65% available chlorine.

One way to think of the "percent available" of the compound we are dealing with is as follows. Because percent is "parts per 100 parts" (see the fraction section for a review of this topic),

"percent available" represents the amount of pure substance, in pounds, per 100 pounds of compound. Given that we have 65% available chlorine, we can easily calculate how many pounds of pure chemical are available provided we know how many pounds of compound we have.

Example: How many pounds of chlorine are in 4 lbs of a compound that has 65% available chlorine?

Solution: We calculate this by multiplying the weight of pure chlorine in the 65% pure compound, by the number of pounds of compound we have.

$$\frac{65 \text{ lbs pure chlorine}}{100 \text{ lbs of cmpd}} \times \frac{4 \text{ lbs of compound (cmpd)}}{1} = 2.6 \text{ lbs pure } Cl_2$$

Therefore, 2.6 lbs of pure chlorine are contained in 4 lbs of a compound that has 65% available chlorine. The following sample problems will give you more practice.

SAMPLE PROBLEMS:

How many pounds of chlorine are in 10 lbs of a compound that has 65% available chlorine??

Suppose we are given a situation where a known volume of water is pumped on a daily basis and we desire to maintain a particular chlorine concentration in a drinking water. If we calculate, we need 9 lbs of 100% available chlorine to provide this concentration, how do we calculate how many pounds of 65% available chlorine we need for this?

If we think of "X" as the amount of 65% available chlorine needed to equal 9 lbs of 100% available chlorine, then

$$\frac{\text{65 lbs of pure chlorine}}{\text{100 lbs compound}} \times \text{"X"} = \text{9 lbs pure chlorine}$$

Solve for "X" by multiplying both sides by $\frac{\text{100 lbs cmpd}}{\text{65 lbs pure}}$

$$X = \frac{\text{9 lbs pure}}{1} \times \frac{\text{100 lbs cmpd}}{\text{65 lbs pure}}$$

$$X = \text{14 lbs cmpd}$$

Therefore, we need 14 lbs of 65% available chlorine. We need more chemical compound when the percent availability is less than 100% than we do with a chemical compound of 100% availability.

Sometimes the compound that contains the desired chemical is liquid. Before the amount of available chemical is detem1ined, the weight of the compound must be calculated.

Example How many pounds of chlorine are in 5 gallons of compound that weighs 10 pounds per gallon and has 10% available chlorine??

Solution $5 \text{ gallon compound} \times \frac{10 \text{ lbs}}{1 \text{ gal}} = 50 \text{ lbs of compound}$

Since the compound has a 10% chlorine availability

10% of 50 lbs = 0.10 x 50 lbs = 5 lbs of pure chlorine

By combining the various techniques discussed above with volume calculations, we can work computations involving disinfection of water mains.

Example How many gallons of liquid chlorine (5.25 % available chlorine) would be required to apply 50 ppm chlorine to 500 feet of new 6 inch watermain?? Assume liquid chlorine weighs 10 lbs/gallon.

Solution Diameter is 6 inches = 0.5 feet

Volume = area x length = $(0.785 \times d^2) \times L$

$V = 0.785 \times (0.5\text{ft})^2 \times 500 \text{ ft} = 98 \text{ ft}^3$ of water to apply chlorine to

$98 \text{ ft}^3 \times 62.4 \text{ lbs/ft}^3 = 6{,}100 \text{ lbs}$

$6{,}100 \text{ lbs} \times \frac{\text{M lbs water}}{1{,}000{,}000 \text{ lbs}} = 0.0061 \text{ M lbs water}$

We know $\text{ppm} = \frac{\text{lbs chemical (chlorine)}}{\text{million lbs water}} \Rightarrow 50\text{ppm} = \frac{\text{lbs of pure chlorine}}{0.0061}$

so, lbs of chlorine = ppm x million lbs water

50 x 0.0061 = 0.31 lbs of 100% chlorine

= 0.31 lbs pure

We know how many lbs of pure chlorine we need, how many lbs of 5.25% available chlorine do we need?

$$\frac{5.25 \text{ lbs pure}}{100 \text{ lbs cmpd}} \times \text{"X"} = 0.31 \text{ lbs } 100\% \text{ available } Cl_2$$

Solving for "X", we get

$$X = 0.31 \text{ lbs pure} \times \frac{100 \text{ lbs cmpd}}{5.25 \text{ lbs pure}}$$

$$X = 5.9 \text{ lbs of cmpd}$$

Now determine the gallons of liquid chlorine needed. Since our compound weighs 10 lbs/gal,

$$5.9 \text{ lbs} \times \frac{1 \text{ gal}}{10 \text{ lbs}} = 0.59 \text{ gal } 5.25\% \text{ liquid } Cl_2$$

SAMPLE PROBLEMS

How many pounds of chlorine are in 9 gallons of a solution that weighs 10 pounds per gallon and has 5% available chlorine??

How many pounds of calcium hypochlorite (65% available chlorine) would be required to disinfect 800 feet of 8-inch water main with 50 ppm of chlorine??

As in math there is multiple ways to solve the same question. In the above examples we explored the concept of conve11ing from pure chlorine to a compound containing 5.25% available chlorine.

Recall, this question earlier:

$$X = 0.31 \text{ lbs } \cancel{\text{pure}} \times \frac{100 \text{ lbs compound}}{5.25 \text{ lbs } \cancel{\text{pure}}} = \qquad X = 5.9 \text{ lbs of compound}$$

In order to do what is being done above one must pull this unit conversion factor from the stated question. Trying to imagine an a11ificial amount of I00 pounds of something without physically seeing it can be hard. Let's try something else that some people will find easier to visualize. In a given question, there will be a percentage that represents the actual available percentage of a pure element in a compound. Earlier, in this course you learned **how to convert percentage to decimals by simply moving the decimal point within the percentage two places to the left.**

<u>**RECALL:**</u> 72.00% ➡ 72.00% = 0.72

Percentages will be given in any chemical addition question. Here is another approach to using percentages. For some trying to use the method on the previous page is hard to grasp.

To summarize this "Rule of Thumb":

Going from compound to pure, you multiple by the percent.

Going from pure to compound, you divide by the percent.

<u>Example</u>: How many gallons of liquid chlorine (5.25% available chlorine) would be required to apply 50 ppm chlorine to 500 feet of new 6-inch watermain? Assume liquid chlorine weighs 10 lbs/gallon.

<u>Solution:</u> Diameter is 6 inches. Convert to feet by dividing by 12 = 0.5 feet

Volume = area x length = $(0.785 \times d^2) \times L$

$V = 0.785 \times 0.5 \times 0.5 \times 500 = 98 ft^3$ of water supply to apply chlorine to

$98 ft^3 \times 7.48 gal/ft^3 \times 8.34$ lbs/gal = 6100 lbs of water

$$\frac{6100 \text{ lbs of water}}{1{,}000{,}000 \text{ lbs of water}} = 0.0061 \text{ M lbs of water}$$

$$\text{We know ppm} = \frac{\text{lbs of pure chemical}}{\text{M lbs of Water}}$$

So lbs of pure chemical = ppm x M lbs of Water

50 ppm x 0.0061 M lbs of Water = 0.31 lbs of pure chlorine

We now know how many pounds of pure chlorine we need, but the problem asks for gallons of a liquid chlorine compound, how do we convert to this?

FRACTIONS, DECIMALS & PERCENTS

PROBLEMS

Write the decimal equivalent of the following percentages.

1. 68% = ________

2. 10% = ________

3. 1% = ________

4. 0.9% = ________

5. 85% = ________

Express the following decimals in percentages

6. 0.04 = ________

7. 0.91 = ________

8. 1.52 = ________

9. 0.001 = ________

10. 0.29 = ________

FRACTIONS, DECIMALS & PERCENTS

PROBLEMS

Make the following calculations.

11. 27% of 503 = ________

12. 11% of 1900 = ________

13. A 21000 gallon tank is 62% full How many gallons is this?

    Answer______________

14. Eighty percent (80%) of a compound is pure, the rest is inert. How many pounds of Insert material are there in 750 lbs of this compound?

    Answer______________

15. A water plant operating at 4/6 capacity is processing 4.5 MGD. What is the plant's full capacity?

    Answer______________

FRACTIONS, DECIMALS & PERCENTS

PROBLEMS

Convert these fractions to their decimal equivalents.

1. $\frac{1}{6}$ = ________

2. $\frac{7}{12}$ = ________

3. $\frac{89}{103}$ = ________

4. $\frac{9}{41}$ = ________

5. $\frac{7}{21}$ = ________

Make the following calculations.

6. $\frac{4}{9} + \frac{5}{7} + \frac{2}{5} + \frac{3}{12}$ = ________

7. $\left(\frac{8}{9} \times \frac{3}{4}\right) - \left(\frac{1}{5} \times \frac{1}{3}\right)$ = ________

8. $\left(\frac{3}{4} \div \frac{1}{3}\right) + \left(\frac{3}{5} + \frac{2}{3}\right)$ = ________

FRACTIONS, DECIMALS & PERCENTS

PROBLEMS

Make the following calculations, rounding off as appropriate.

1. $(49.2 \div 19) \times (72.5 \div 26) =$ ______________

2. $2100 \div 20 \div 12 =$ ______________

3 $810 \div 8 \times 6 =$ ______________

4. $(0.41 - 0.15) \div 0.5 =$ ______________

5. $(122.8 \div 21) + 31 =$ ______________

6. $21.74 \div (0.7l \times 0.92) =$ ______________

7. $\dfrac{(5.13 + 2.79)}{(2.14 + 8.01)} =$ ______________

8. $(1.05 + 14.51 - 12.0) \div 0.452 =$ ______________

UNITS AND CONVERSIONS

PROBLEMS

1. Convert 400 gallons of water to cubic feet.

2. Convert 290 gallons of water to pounds.

3. A tank has a capacity of 77,000 cubic feet.

   a. What is the gallon capacity of the tank?

   b. How many pounds does the water weigh in the tank?

4. Convert 45 cubic feet of water to pounds.

UNITS AND CONVERSIONS

PROBLEMS

5 Convert 650 fpm to fps

6 Convert 700 gpm to gpd

7. Convert 9 cfs to gpm

8. Convert 600 gpm to cfs

AREAS & VOLUMES

PROBLEMS

1. What is the area of a filter that is 30 feet long and 15 feet wide?

2. A water main has a diameter of 8 inches. What is the cross sectional area of the main in square feet?

3 In laying a new water main, a trench 8 ft wide, 10 ft deep, and 1200 ft long is excavated.

a. How many cubic feet of soil are removed?

b. How many cubic yards is this?

AREAS & VOLUMES
PROBLEMS

4. If 2100 feet of 30-inch main is laid, approximately how many cubic yards of soil will be displaced by the main itself?

5. What is the volume of a tank that is 36 feet long, by 14 feet wide, by 10 feet deep?

6. How many gallons will the tank hold if the tank overflow is located 8 feet above the floor?

AREAS & VOLUMES

PROBLEMS

<u>Bonus Question</u>

7. An empty tank measures 95 feet long, 25 feet wide, and 18 feet deep. If 211,900 gallons are pumped into the tank, how high will the level of the water in the tank rise?

CHLORINE REVIEW PROBLEMS

How many pounds of chlorine are in 6 gallons of a solution that weighs 10 pounds per gallon and has 10% available chlorine?

How many pounds of chlorine are in 9 gallons of a solution that weighs 10 pounds per gallon and has 5% available chlorine?

Eight pounds of chlorine in 650,000 lbs of water equals what concentration in ppm?

Five pounds of chlorine in 300,000 lbs of water equals what concentration in ppm?

If 65 pounds of chlorine are added to 6 million gallons of water, what is the concentration of chlorine?

What is the concentration of chlorine if 22 pounds of chlorine are added to 275,000 gallons of water?

What is the concentration of chlorine if 17 pounds of chlorine are added to 120,000 gallons of water?

How many pounds of chlorine are in a 20 gallon solution that weighs 10.4 pounds per gallon and has 5.25% available chlorine?

Calculate how much HTH powder in pounds (65% available chlorine) would be required to obtain a chlorine dose of 75 ppm in an elevated water tank 45 feet in diameter and 70 feet deep.

How many gallons of bleach (5.25% available chlorine) would be required to apply 50 ppm chlorine to 500 feet of new 6-inch water main? Assume bleach weighs10 lbs/gallon.

How many pounds of calcium hypochlorite (65% available chlorine) would be required to disinfect 1,000 feet of 12-inch water main with 50 ppm of chlorine? ·

A new 18-inch well must be disinfected. You want a chlorine residual of 125 ppm. The depth of the well is 1000 feet and the static water level is 200 feet below the top of the casing. How many pounds of chlorine will you need?

You are required to add chlorine to your water supply for disinfection. You have determined that your system has a chlorine demand of 0.9 ppm and you wish to maintain a chlorine residual of 0.5 ppm. The flow through your treatment plant is 11 MGD (million gallons per day). Assume you are using 15% Sodium Hypochlorite and it weighs 10.4 lb/gallon. Your chemical feed pump should be set at.

It is desired to apply 3 mg/l of chlorine to a well which pumps 500 gallons/minute (gpm). How many pounds of chlorine gas are used in one day?

A water supply has a chlorine demand of 3 mg/l. It is desired to maintain a residual throughout the distribution system of 0.4 parts per million. How many gallons of sodium hypochlorite (12% available) are needed to maintain this residual knowing that the water supply pumps 300,000 gallons each day? Assume one gallon of sodium hypochlorite weighs 10.4 pounds.

A water treatment plant treating 10 MGD is prechlorinating with 150 pounds of chlorine gas per day and post chlorinating with 100 pounds of chlorine gas per day. What are the respective prechlornation and post chlorination application rates in mg/l?

Estimate the chlorine dose in mg/l if a chlorinator feeds at a rate of 21 lbs per 24 hours and the flow is 0.60 MGD.

CHLORINATION QUESTIONS

1. How many gallons of sodium hypochlorite (12.5%) are required to disinfect a 6-inch diameter water line that is 1,000 feet long using 50 rng/l chlorine solution? Assume so sodium hypochlorite weighs 10 lb/gal?

2. How much chlorine gas is required to treat 5 million gallons of water to provide a 0.7 residual?

3. How many pounds of available chlorine are there in 50 pounds of 65% calcium hypochlorite?

4. A chlorinator is set to feed 20 pounds of chlorine in 24 hours to a flow of 0.85 MGD. Find the chlorine dose in mg/L.

5. What should be the setting on a chlorinator (lbs chlorine per 24 hours) if the service pump usually delivers 600 gpm and the desired chlorine dosage is 4.0 rng/L?

6. How many pounds of 65% HTH chlorine will be required to disinfect 400 feet of 8-inch watermain at 50 ppm?

7. What should the chlorinator setting be (lbs/day) to treat a flow of 2 MGD if the chlorine demand is 5 rng/l and a chlorine residual of 0.8 mg/l Is desired?

8. How many pounds per day of HTH (65% available chlorine) are required to disinfect 10,000 feet of 8-inch water line if an initial dose of 20 mg/l is required?

9. Your water has a chlorine demand of 1.4 ppm and you desire a residual of 0.7 ppm. What should your chlorine dose be?

10 . A new 12-inch well must be disinfected. You want a chlorine residual of 100 ppm. The depth of the well is 1000 feet and the static water level is 300 feet below the top of the casing. How many pounds of chlorine will you need?

11. The pump in your main well has been replaced. The well driller dumps 6 pounds of HTH down the well for disinfection. What is the concentration of Cl in the well?

Assume: HTH contains 65% available chlorine; Well diameter = 18 inches for the entire well depth

Well depth = 600 feet; Static water level = 150 feet below top of casing

12. You are required to add chlorine to your water supply for disinfection. You have determined that your system has a chlorine demand of 0.8 ppm and you wish to maintain a chlorine residual of 0.5 ppm. The flow through your treatment plant is MGD. Assume 100% available chlorine. Your chlorinator should be set at.

13. What is the chlorine dose if you apply 120 pounds of 12.5% sodium hypochlorite in 2 days with a flow of 2.5 MGD?

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14. As water superintendent, you must determine the chemical costs of chlorinating your water supply, Assume the following data applies to your system:

Average daily pumpage = 1.5 MGD
Average chlorine demand = 1.0 ppm
Desired chlorine residual = 0.3 ppm
Gas chlorine at 19 cents per pound
What would be the yearly chlorine costs?

15. A barrel 13 feet tall and 2.5 feet in diameter is filled with sodium hypochlorite. This chlorine solution is fed to a well pumps for 16 hours at a rate of 400 gpm. After this period of time, the level In the barrel has dropped 9 inches. How many pounds of sodium hypochlorite is used? Assume NaOCI contains 12.5% available chlorine and weighs 10 lbs/gal.

REALLY BASIC MATH

REVIEW PROBLEMS

1. Write the decimal equivalent of the following percentages.

   a. 37% =

   b. 12% =

   c. 62% =

   d. .9% =

   e. 3% =

   f. 317% =

   g. 29% =

   h. 47% =

   i. 71% =

2. Express the following decimals in percentages.

   a. 0.02 =

   b. 0.31 =

   c. 2.04 =

   d. 0.57 =

   e. 0.84 =

   f. 1.12 =

   g. 0 22 =

   h. 0.71 =

   i. 0.99 =

REALLY BASIC MATH

REVIEW PROBLEMS

3. Make the following calculations.

   a. 21% of 2450 =

   b. 19% of 1100 =

   c. 7/9 of 9800 =

   d. (5/8 + 0.74) -0.13 =

   e. (1.44 x 2/3) + 24 =

   f. 5.2 x 2 + 12 =

   g. A 105,000 gallon tank is 80% full. How many gallons is this?

   h. A 5.7 MGD water plant is operating at 4/5 capacity. how many gallons is it processing?

   i. A conventional sand filter can filter 25,000 gallons of water an hour it is operating at 65% capacity, how many gallons of water is it processing in 24 hours?

   j. How many gallons of chemical are in a 55 gallon drum that is 27% full?

4. Sixty-five percent (65%) of a compound is pure, the rest is inert. How many pounds of pure material and how many pounds of insert material are there in 825 lbs of this compound?

Pounds pure = ____________________

Pounds inert =_____________________

REALLY BASIC MATH

REVIEW PROBLEMS

5. A water plant operating at 5/8 capacity. If full capacity is 4.4 MGD, how much water is the plant producing?

   Answer

6. Convent:

   a. 750 gallons of water to cubic feet. Answer________________

   b. 42 cubic feet or water to pounds. Answer________________

   c. 210 gallons of water to pounds. Answer________________

   d. 2.7 years to days Answer________________

   e. 1.8 miles to yards Answer________________

   f. 1. 1 years to second Answer________________

REALLY BASIC MATH

REVIEW PROBLEMS

7. If the water plant has a water tank that is 40 feet long, 14 feet wide, and 12 feet deep is 60% full. how many gallons of water are in the tank? How many pounds of water is there?

8. How many gallons of water does a 10-inch pipe that is 800 feet long hold? How many pounds does the water in the pipe weigh?

9. A 2.2 MGD plant is operating at 2/3 capacity over the course of 7 days. How many gallons of water is the plant producing per day? How many of gallons is the plant producing for the week? How many pounds of water does the plant produce in this week?