

# Formula/Conversion Table

Water Treatment, Distribution, & Water Laboratory Exams



$$\text{Alkalinity, mg/L as CaCO}_3 = \frac{(\text{Titrant Volume, mL})(\text{Acid Normality})(50,000)}{\text{Sample Volume, mL}}$$

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

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

$$\text{Area of Circle} = (3.14)(\text{Radius}^2)$$

$$\text{Area of Cone (lateral area)} = (3.14)(\text{Radius})\sqrt{\text{Radius}^2 + \text{Height}^2}$$

$$\text{Area of Cone (total surface area)} = (3.14)(\text{Radius})(\text{Radius} + \sqrt{\text{Radius}^2 + \text{Height}^2})$$

$$\text{Area of Cylinder (total exterior surface area)} = [\text{End \#1 SA}] + [\text{End \#2 SA}] + [(3.14)(\text{Diameter})(\text{Height or Depth})]$$

Where SA = surface area

$$\text{Area of Rectangle}^* = (\text{Length})(\text{Width})$$

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

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

$$\text{Average (geometric mean)} = [(\text{X}_1)(\text{X}_2)(\text{X}_3)(\text{X}_4)(\text{X}_n)]^{1/n} \quad \text{The } n\text{th root of the product of } n \text{ numbers}$$

$$\text{Blending or Three Normal Equation} = (\text{C}_1 \times \text{V}_1) + (\text{C}_2 \times \text{V}_2) = (\text{C}_3 \times \text{V}_3)$$

Where  $\text{V}_1 + \text{V}_2 = \text{V}_3$ ; C = concentration,  
V = volume or flow; Concentration units must match; Volume units must match

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

$$\text{Chemical Feed Pump Setting, mL/min} =$$

$$\frac{(\text{Flow, MGD})(\text{Dose, mg/L})(3.785 \text{ L/gal})(1,000,000 \text{ gal/MG})}{(\text{Feed Chemical Density, mg/mL})(\text{Active Chemical, \% expressed as a decimal})(1,440 \text{ min/day})}$$

$$\text{Chemical Feed Pump Setting, mL/min} =$$

$$\frac{(\text{Flow, m}^3/\text{day})(\text{Dose, mg/L})}{(\text{Feed Chemical Density, g/cm}^3)(\text{Active Chemical, \% expressed as a decimal})(1,440 \text{ min/day})}$$

$$\text{Circumference of Circle} = (3.14)(\text{Diameter})$$

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

$$\text{CT Calculation} = (\text{Disinfectant Residual Concentration, mg/L})(\text{Time, min})$$

\*Pie Wheel Format for this equation is available at the end of this document

$$\text{Degrees Celsius} = \frac{(^{\circ}\text{F} - 32)}{1.8}$$

$$\text{Degrees Fahrenheit} = (^{\circ}\text{C})(1.8) + 32$$

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}} \quad \text{Units must be compatible}$$

$$\text{Dilution or Two Normal Equation} = (C_1 \times V_1) = (C_2 \times V_2) \quad \text{Where } C = \text{Concentration, } V = \text{volume or flow;}$$

*Concentration units must match;*  
*Volume units must match*

$$\text{Electromotive Force, volts}^* = (\text{Current, amps})(\text{Resistance, ohms})$$

$$\text{Feed Rate, lb/day}^* = \frac{(\text{Dosage, mg/L})(\text{Flow, MGD})(8.34 \text{ lb/gal})}{\text{Purity, \% expressed as a decimal}}$$

$$\text{Feed Rate, kg/day}^* = \frac{(\text{Dosage, mg/L})(\text{Flow Rate, m}^3/\text{day})}{(\text{Purity, \% expressed as a decimal})(1,000)}$$

$$\text{Feed Rate (Fluoride), lb/day} = \frac{(\text{Dosage, mg/L})(\text{Capacity, MGD})(8.34 \text{ lb/gal})}{(\text{Available Fluoride Ion, \% expressed as a decimal})(\text{Purity, \% expressed as a decimal})}$$

$$\text{Feed Rate (Fluoride), kg/day} = \frac{(\text{Dosage, mg/L})(\text{Capacity, m}^3/\text{day})}{(\text{Available Fluoride Ion, \% expressed as a decimal})(\text{Purity, \% expressed as a decimal})(1,000)}$$

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

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

$$\text{Filter Backwash Rise Rate, in/min} = \frac{(\text{Backwash Rate, gpm/ft}^2)(12 \text{ in/ft})}{7.48 \text{ gal/ft}^3}$$

$$\text{Filter Backwash Rise Rate, cm/min} = \frac{\text{Water Rise, cm}}{\text{Time, min}}$$

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

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

$$\text{Filter Loading Rate, gpm/ft}^2 = \frac{\text{Flow, gpm}}{\text{Filter area, ft}^2}$$

\*Pie Wheel Format for this equation is available at the end of this document

$$\text{Filter Loading Rate, L/sec/m}^2 = \frac{\text{Flow, L/sec}}{\text{Filter area, m}^2}$$

$$\text{Filter Yield, lb/hr/ft}^2 = \frac{(\text{Solids Loading, lb/day})(\text{Recovery, \% expressed as a decimal})}{(\text{Filter Operation, hr/day})(\text{Area, ft}^2)}$$

$$\text{Filter Yield, kg/hr/m}^2 = \frac{(\text{Solids Concentration, \% expressed as a decimal})(\text{Sludge Feed Rate, L/hr})(10)}{(\text{Surface Area of Filter, m}^2)}$$

$$\text{Flow Rate, ft}^3/\text{sec}^* = (\text{Area, ft}^2)(\text{Velocity, ft/sec})$$

$$\text{Flow Rate, m}^3/\text{sec}^* = (\text{Area, m}^2)(\text{Velocity, m/sec})$$

$$\text{Force, lb}^* = (\text{Pressure, psi})(\text{Area, in}^2)$$

$$\text{Force, newtons}^* = (\text{Pressure, pascals})(\text{Area, m}^2)$$

$$\text{Hardness, as mg CaCO}_3/\text{L} = \frac{(\text{Titrant Volume, mL})(1,000)}{\text{Sample Volume, mL}} \quad \text{Only when the titration factor is 1.00 of EDTA}$$

$$\text{Horsepower, Brake, hp} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{(3,960)(\text{Pump Efficiency, \% expressed as a decimal})}$$

$$\text{Horsepower, Brake, kW} = \frac{(9.8)(\text{Flow, m}^3/\text{sec})(\text{Head, m})}{(\text{Pump Efficiency, \% expressed as a decimal})}$$

$$\text{Horsepower, Motor, hp} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{(3,960)(\text{Pump Efficiency, \% expressed as a decimal})(\text{Motor Efficiency, \% expressed as a decimal})}$$

$$\text{Horsepower, Motor, kW} = \frac{(9.8)(\text{Flow, m}^3/\text{sec})(\text{Head, m})}{(\text{Pump Efficiency, \% expressed as a decimal})(\text{Motor Efficiency, \% expressed as a decimal})}$$

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

$$\text{Horsepower, Water, kW} = (9.8)(\text{Flow, m}^3/\text{sec})(\text{Head, m})$$

$$\text{Hydraulic Loading Rate, gpd/ft}^2 = \frac{\text{Total Flow Applied, gpd}}{\text{Area, ft}^2}$$

$$\text{Hydraulic Loading Rate, m}^3/\text{day/m}^2 = \frac{\text{Total Flow Applied, m}^3/\text{day}}{\text{Area, m}^2}$$

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

$$\text{Hypochlorite Strength, \%} = \frac{(\text{Chlorine Required, kg})(100)}{(\text{Hypochlorite Solution Needed, kg})}$$

\*Pie Wheel Format for this equation is available at the end of this document

**Langelier Saturation Index** = pH – pHs

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

$$\text{Leakage, Lpd} = \frac{\text{Volume, L}}{\text{Time, days}}$$

$$\text{Loading Rate, lb/day*} = (\text{Flow, MGD})(\text{Concentration, mg/L})(8.34 \text{ lb/gal})$$

$$\text{Loading Rate, kg/day*} = \frac{(\text{Flow, m}^3/\text{day})(\text{Concentration, mg/L})}{1,000}$$

$$\text{Mass, lb*} = (\text{Volume, MG})(\text{Concentration, mg/L})(8.34 \text{ lb/gal})$$

$$\text{Mass, kg*} = \frac{(\text{Volume, m}^3)(\text{Concentration, mg/L})}{1,000}$$

$$\text{Milliequivalent} = (\text{mL})(\text{Normality})$$

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

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

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

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

$$\text{Power, kW} = \frac{(\text{Flow, L/sec})(\text{Head, m})(9.8)}{1,000}$$

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

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

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

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

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

$$\text{Specific Gravity} = \frac{\text{Specific Weight of Substance, lb/gal}}{8.34 \text{ lb/gal}}$$

\*Pie Wheel Format for this equation is available at the end of this document

$$\text{Specific Gravity} = \frac{\text{Specific Weight of Substance, kg/L}}{1.0, \text{ kg/L}}$$

$$\text{Surface Loading Rate or Surface Overflow Rate, gpd/ft}^2 = \frac{\text{Flow, gpd}}{\text{Area, ft}^2}$$

$$\text{Surface Loading Rate or Surface Overflow Rate, Lpd/m}^2 = \frac{\text{Flow, Lpd}}{\text{Area, m}^2}$$

$$\text{Threshold Odor Number} = \frac{A+B}{A} \quad \text{Where } A = \text{volume of odor causing sample, } B = \text{volume of odor free water}$$

$$\text{Velocity, ft/sec} = \frac{\text{Flow Rate, ft}^3 / \text{sec}}{\text{Area, ft}^2}$$

$$\text{Velocity, ft/sec} = \frac{\text{Distance, ft}}{\text{Time, sec}}$$

$$\text{Velocity, m/sec} = \frac{\text{Flow Rate, m}^3 / \text{sec}}{\text{Area, m}^2}$$

$$\text{Velocity, m/sec} = \frac{\text{Distance, m}}{\text{Time, sec}}$$

$$\text{Volume of Cone}^* = (1/3)(0.785)(\text{Diameter}^2)(\text{Height})$$

$$\text{Volume of Cylinder}^* = (0.785)(\text{Diameter}^2)(\text{Height})$$

$$\text{Volume of Rectangular Tank}^* = (\text{Length})(\text{Width})(\text{Height})$$

$$\text{Water Use, gpcd} = \frac{\text{Volume of Water Produced, gpd}}{\text{Population}}$$

$$\text{Water Use, Lpcd} = \frac{\text{Volume of Water Produced, Lpd}}{\text{Population}}$$

$$\text{Watts (AC circuit)} = (\text{Volts})(\text{Amps})(\text{Power Factor})$$

$$\text{Watts (DC circuit)} = (\text{Volts})(\text{Amps})$$

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

$$\text{Weir Overflow Rate, Lpd/m} = \frac{\text{Flow, Lpd}}{\text{Weir Length, m}}$$

$$\text{Wire-to-Water Efficiency, \%} = \frac{\text{Water hp}}{\text{Motor hp}} \times 100\%$$

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

\*Pie Wheel Format for this equation is available at the end of this document

## Abbreviations

<b>C</b> .....	Celsius	<b>Lpm</b> .....	liters per minute
<b>cfs</b> .....	cubic feet per second	<b>LSI</b> .....	Langelier Saturation Index
<b>cm</b> .....	centimeters	<b>m</b> .....	meters
<b>DO</b> .....	dissolved oxygen	<b>mg</b> .....	milligrams
<b>EMF</b> .....	electromotive force	<b>MG</b> .....	million gallons
<b>F</b> .....	Fahrenheit	<b>MGD</b> .....	million US gallons per day
<b>ft</b> .....	feet	<b>min</b> .....	minutes
<b>ft lb</b> .....	foot-pound	<b>mL</b> .....	milliliters
<b>g</b> .....	grams	<b>ML</b> .....	million liters
<b>gal</b> .....	US gallons	<b>MLD</b> .....	million liters per day
<b>gfd</b> .....	US gallons flux per day	<b>ORP</b> .....	oxidation reduction potential
<b>gpcd</b> .....	US gallons per capita per day	<b>ppb</b> .....	parts per billion
<b>gpd</b> .....	US gallons per day	<b>ppm</b> .....	parts per million
<b>gpg</b> .....	grains per US gallon	<b>psi</b> .....	pounds per square inch
<b>gpm</b> .....	US gallons per minute	<b>Q</b> .....	flow
<b>hp</b> .....	horsepower	<b>RPM</b> .....	revolutions per minute
<b>hr</b> .....	hours	<b>SDI</b> .....	sludge density index
<b>in</b> .....	inches	<b>sec</b> .....	second
<b>kg</b> .....	kilograms	<b>SS</b> .....	settleable solids
<b>km</b> .....	kilometers	<b>TOC</b> .....	total organic carbon
<b>kPa</b> .....	kilopascals	<b>TSS</b> .....	total suspended solids
<b>kW</b> .....	kilowatts	<b>TTHM</b> .....	total trihalomethanes
<b>kWh</b> .....	kilowatt-hours	<b>VS</b> .....	volatile solids
<b>L</b> .....	liters	<b>W</b> .....	watts
<b>lb</b> .....	pounds	<b>yd</b> .....	yards
<b>Lpcd</b> .....	liters per capita per day	<b>yr</b> .....	year
<b>Lpd</b> .....	liters per day		

## Conversion Factors

<b>1 acre</b> .....	= 43,560 ft <sup>2</sup> = 4,046.9 m <sup>2</sup>	<b>1 inch</b> .....	= 2.54 cm
<b>1 acre foot of water</b> .....	= 326,000 gal	<b>1 liter per second</b> .....	= 0.0864 MLD
<b>1 cubic foot of water</b> .....	= 7.48 gal = 62.4 lb	<b>1 meter of water</b> .....	= 9.8 kPa
<b>1 cubic foot per second</b> .....	= 0.646 MGD = 448.8 gpm	<b>1 metric ton</b> .....	= 2,205 lb = 1,000 kg
<b>1 cubic meter of water</b> .....	= 1,000 kg = 1,000 L = 264 gal	<b>1 mile</b> .....	= 5,280 ft = 1.61 km
<b>1 foot</b> .....	= 0.305 m	<b>1 million US gallons per day</b> ...	= 694 gpm = 1.55 ft <sup>3</sup> /sec
<b>1 foot of water</b> .....	= 0.433 psi	<b>1 pound</b> .....	= 0.454 kg
<b>1 gallon (US)</b> .....	= 3.785 L = 8.34 lb of water	<b>1 pound per square inch</b> .....	= 2.31 ft of water = 6.89 kPa
<b>1 grain per US gallon</b> .....	= 17.1 mg/L	<b>1 square meter</b> .....	= 1.19 yd <sup>2</sup>
<b>1 hectare</b> .....	= 10,000 m <sup>2</sup>	<b>1 ton</b> .....	= 2,000 lb
<b>1 horsepower</b> .....	= 0.746 kW = 746 W = 33,000 ft lb/min	<b>1%</b> .....	= 10,000 mg/L
		<b>π or pi</b> .....	= 3.14

## Alkalinity Relationships

All Alkalinity expressed as mg/L as CaCO<sub>3</sub> ● P – phenolphthalein alkalinity ● T – total alkalinity

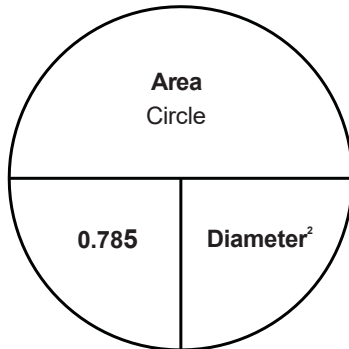
Result of Titration	Hydroxide Alkalinity	Carbonate Alkalinity	Bicarbonate Concentration
P = 0	0	0	T
P < ½T	0	2P	T – 2P
P = ½T	0	2P	0
P > ½T	2P – T	2(T – P)	0
P = T	T	0	0

\*Pie Wheel Format for this equation is available at the end of this document

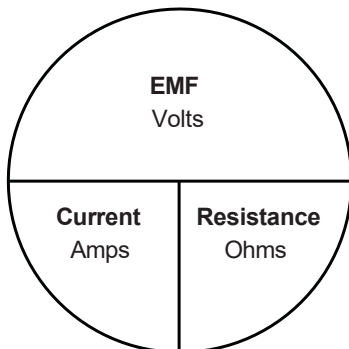
## \*Pie Wheels

- To find the quantity above the horizontal line: multiply the pie wedges below the line together.
- To solve for one of the pie wedges below the horizontal line: cover that pie wedge, then divide the remaining pie wedge(s) into the quantity above the horizontal line.
- Given units must match the units shown in the pie wheel.
- When US and metric units or values differ, the metric is shown in parentheses, e.g. (m<sup>2</sup>).

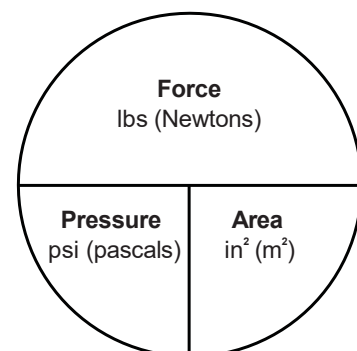
**Area of Circle**



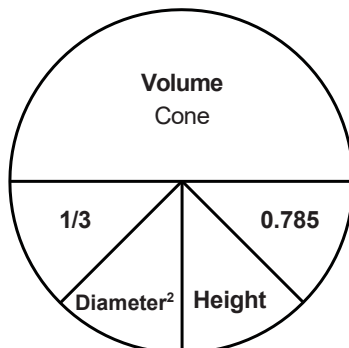
**Electromotive Force (EMF), Volts**



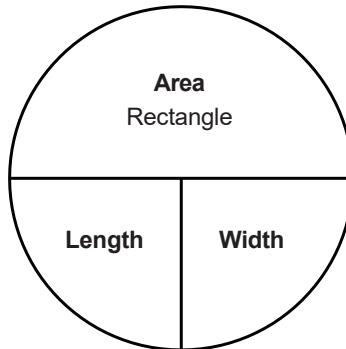
**Force, lbs (Newtons)**



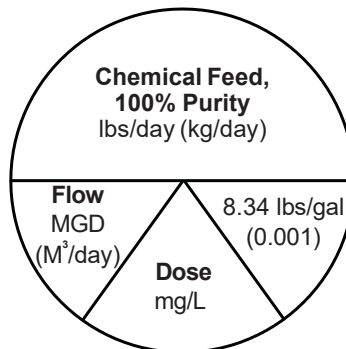
**Volume of Cone**



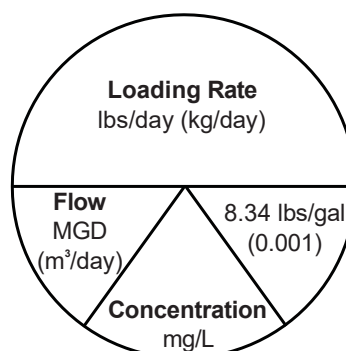
**Area of Rectangle**



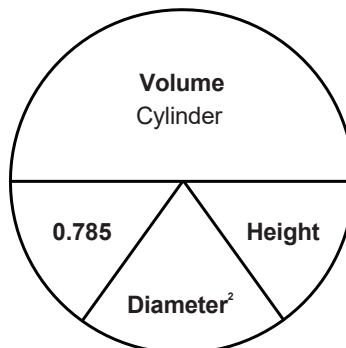
**Feed Rate, lbs/day (kg/day)**



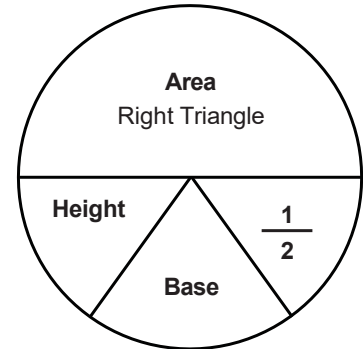
**Loading Rate, lbs/day (kg/day)**



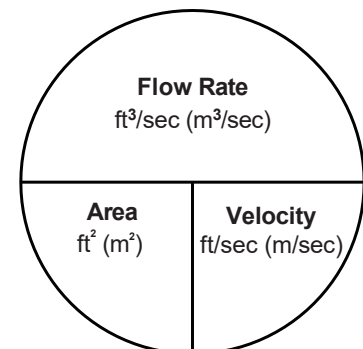
**Volume of Cylinder**



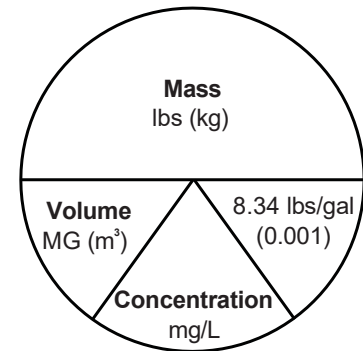
**Area of Right Triangle**



**Flow Rate, ft<sup>3</sup>/sec (m<sup>3</sup>/sec)**



**Mass, lbs (kg)**



**Volume of Rectangular Tank**

