



## Drinking Water Operator Certification

# Exam Math Formulas

### Conversion Factors

1 ft <sup>3</sup>	=	7.48 gallons
1 gallon of H <sub>2</sub> O	=	8.34 lbs
1 mg/L	=	1 ppm
1 mile	=	5280 feet
1 acre	=	43560 ft <sup>2</sup>
1 psi	=	2.31 feet of head
1 horsepower	=	0.746 kilowatts
1 ppb	=	1ug/L
1 gallon	=	8 pints
1 gallon	=	3.78 liters
1 feet of head	=	0.433 psi

1 ft <sup>3</sup> 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 yard <sup>3</sup>	=	27 ft <sup>3</sup>
1 kilogram	=	2.2 lbs
1 lbs	=	454 grams
1 kilograms	=	1000 grams
1 liter	=	1000 mL
1 ton	=	2000 lbs

#### 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 Diameter <sup>2</sup>
Circle	=	π [ x radius ] <sup>2</sup>
Triangle	=	0.5 x base x height
Sphere	=	4 x π [ x radius ] <sup>2</sup>
Cylinder	=	(2 x π x r x h) + (2 x π x r <sup>2</sup> )

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

#### Volumes

Cone: V	=	1/3 x 0.785 x D <sup>2</sup> x H
Cone: V	=	1/3 x π x R <sup>2</sup> x H
Cylinder: V	=	π x R <sup>2</sup> x H
Cylinder: V	=	0.785 x D <sup>2</sup> x H
Rectangular Prism: V	=	L x W x H
Pyramid: V	=	L x W x (1/3)H
Sphere: V	=	4/3(πr <sup>3</sup> )

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

## Water-Brake-Motor Horsepower

$$\text{WHP} = \frac{\text{GPM} \times \text{Total Head (ft)}}{3960} \quad \left| \quad \text{BHP} = \frac{\text{GPM} \times \text{Total Head (ft)}}{3960 \times E_p} \quad \right| \quad \text{MHP} = \frac{\text{GPM} \times \text{Total Head (ft)}}{3960 \times E_p \times E_m}$$

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

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

## Alkalinity

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

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

Alkalinity Relationships: Alkalinity, mg/l CaCO<sub>3</sub>

Result of Titration	Hydroxide Alkalinity as CaCO <sub>3</sub>	Carbonate Alkalinity as CaCO <sub>3</sub>	Bicarbonate Concentration as CaCO <sub>3</sub>
P = 0	0	0	T
P < ½ T	0	2P	T - 2P
P = ½ T	0	2P	0
P > ½ T	2P - T	2(T - P)	0
P = T	T	0	0

Key: P – phenolphthalein alkalinity; T – total alkalinity

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## Common Compounds in Water

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Hydrated Alum	$\text{Al}_2(\text{SO}_4)_3 \times 14 \text{H}_2\text{O}$	Chloramine	$\text{NH}_2\text{Cl}$
Calcium Chloride	$\text{CaCl}_2$	Calcium Oxide (Dry Lime)	$\text{CaO}$
Hydrochloric Acid	$\text{HCl}$	Ozone	$\text{O}_3$
Ferric Chloride	$\text{FeCl}_3$	Alum	$\text{Al}_2(\text{SO}_4)_3$
Calcium Bicarbonate	$\text{Ca}(\text{HCO}_3)_2$	Sodium Hypochlorite	$\text{NaOCl}$
Ferric Sulfate	$\text{Fe}_2(\text{SO}_4)_3$	Hydrofluorosilic Acid	$\text{H}_2\text{SiF}_6$
Chlorine Gas	$\text{Cl}_2$	Sulfuric Acid	$\text{H}_2\text{SO}_4$
Calcium Hypochlorite (HTH)	$\text{Ca}(\text{OCl})_2$	Calcium Carbonate	$\text{CaCO}_3$
Sodium Hydroxide	$\text{NaOH}$	Peroxide	$\text{H}_2\text{O}_2$
Sodium Carbonate	$\text{Na}_2\text{CO}_3$	Phosphoric Acid	$\text{H}_3\text{PO}_4$
Hypochlorous Acid	$\text{HOCl}$	Carbon Dioxide	$\text{CO}_2$
Calcium Hydroxide	$\text{Ca}(\text{OH})_2$	Sodium Fluoride	$\text{NaF}$

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## Miscellaneous Formulas

$$\text{Leakage Formula: } L = \frac{S \times D \times \sqrt{P}}{148,000}$$

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)

$$\text{Pumping Rate, GPM} = \frac{\text{volume (gal)}}{\text{time (min)}}$$

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

**Bernoulli's Equation:**

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

**Langlier Index** = pH - pH<sub>s</sub>

**Circumference** =  $\pi \times \text{diameter}$  or  $2 \times \pi \times r$

$$\text{Dilution Equation } C_1V_1 = C_2V_2$$

**Chlorine Dosage** = Demand + Residual

$$\text{PPM} = \frac{\text{lbs. of chemical}}{\text{Million lbs. of H}_2\text{O}}$$

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

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

$$\text{Velocity} = \frac{\text{Distance (ft)}}{\text{Time (sec)}}$$

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

**Hardness, grains/gallon** =

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

**Total Hardness**, mg/L as CaCO<sub>3</sub> = Calcium Hardness, mg/L as CaCO<sub>3</sub> + Magnesium Hardness, mg/L as CaCO<sub>3</sub>

## List of Elements

Name	Symbol	Atomic Mass (in grams)	Name	Symbol	Atomic Mass (in grams)	Name	Symbol	Atomic Mass (in grams)
Actinium	Ac	227.00g	Hafnium	Hf	178.50g	Promethium	Pm	145.00g
Aluminum	Al	26.98g	Hassium	Hs	277.00g	Protactinium	Pa	231.04g
Americium	Am	243.00g	Helium	He	4.00g	Radium	Ra	226.00g
Antimony	Sb	121.76g	Holmium	Ho	164.93g	Radon	Rn	222.00g
Argon	Ar	39.95g	Hydrogen	H	1.01g	Rhenium	Re	186.20g
Arsenic	As	74.92g	Indium	In	114.82g	Rhodium	Rh	102.90g
Astatine	At	210.00g	Iodine	I	126.90g	Rubidium	Rb	85.47g
Barium	Ba	137.33g	Iridium	Ir	192.22g	Ruthenium	Ru	101.00g
Berkelium	Bk	247.00g	Iron	Fe	55.85g	Rutherfordium	Rf	261.00g
Beryllium	Be	9.01g	Krypton	Kr	83.80g	Samarium	Sm	150.36g
Bismuth	Bi	208.98g	Lanthanum	La	138.90g	Scandium	Sc	44.96g
Bohrium	Bh	264.00g	Lawrencium	Lr	262.00g	Seaborgium	Sg	266.00g
Boron	B	10.80g	Lead	Pb	207.20g	Selenium	Se	78.96g
Bromine	Br	79.90g	Lithium	Li	6.94g	Silicon	Si	28.10g
Cadmium	Cd	112.40g	Lutetium	Lu	174.97g	Silver	Ag	107.87g
Calcium	Ca	40.09g	Magnesium	Mg	24.30g	Sodium	Na	23.00g
Californium	Cf	251.00g	Manganese	Mn	54.94g	Strontium	Sr	87.62g
Carbon	C	12.01g	Meitnerium	Mt	268.00g	Sulfur	S	32.06g
Cerium	Ce	140.12g	Mendelevium	Md	258.00g	Tantalum	Ta	180.95g
Cesium	Cs	132.90g	Mercury	Hg	200.6g	Technetium	Tc	98.00g
Chlorine	Cl	35.50g	Molybdenum	Mo	95.94g	Tellurium	Te	127.60g
Chromium	Cr	52.00g	Neodymium	Nd	144.4g	Terbium	Tb	158.93g
Cobalt	Co	58.93g	Neon	Ne	20.20g	Thallium	Tl	204.38g
Copper	Cu	63.55g	Neptunium	Np	237.00g	Thorium	Th	232.04g
Curium	Cm	247.00g	Nickel	Ni	58.69g	Thulium	Tm	168.93g
Dubnium	Db	262.00g	Niobium	Nb	92.90g	Tin	Sn	118.71g
Dysprosium	Dy	162.50g	Nitrogen	N	14.01g	Titanium	Ti	47.87g
Einsteinium	Es	252.00g	Nobelium	No	259.00g	Tungsten	W	183.84g
Erbium	Er	167.26g	Osmium	Os	190.23g	Uranium	U	238.03g
Europium	Eu	151.96g	Oxygen	O	16.00g	Vanadium	V	50.94g
Fermium	Fm	257.00g	Palladium	Pd	106.42g	Xenon	Xe	131.30g
Fluorine	F	19.00g	Phosphorous	P	30.97g	Ytterbium	Yb	173.04g
Francium	Fr	223.00g	Platinum	Pt	195.07g	Yttrium	Y	88.90g
Gadolinium	Gd	157.25g	Plutonium	Pu	244.00g	Zinc	Zn	65.39g
Gallium	Ga	69.72g	Polonium	Po	209.00g	Zirconium	Zr	91.22g
Germanium	Ge	72.64g	Potassium	K	39.10g			
Gold	Au	196.97g	Praseodymium	Pr	140.90g			

## Table of Softening Mass Conversions

Source of demand and chemical dose required

<b>SOURCE OF DEMAND*</b>	<b>LIME (MG/L AS CAO)</b>	<b>SODA ASH (MG/L AS NA<sub>2</sub>CO<sub>3</sub>)</b>
CO <sub>2</sub> (MG/L AS CO <sub>2</sub> )	1.27	-
CA <sup>2+</sup> CARBONATE HARDNESS	0.56	-
MG <sup>2+</sup> CARBONATE HARDNESS	1.12	-
MG <sup>2+</sup> NCH	0.56	1.06
CA <sup>2+</sup> NCH	-	1.06
EXCESS LIME	0.56	-
EXCESS SODA ASH	-	1.06

\*All units are "as CaCO<sub>3</sub>" unless specified