



MATH FOR WATER TREATMENT OPERATORS:

Practice Problems to Prepare for Water
Treatment Operator Certification Exams

John Giorgi



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Practice Problems to Prepare for
Water Treatment Operator
Certification Exams

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FIRST EDITION



**American Water Works
Association**

Disclaimer

Although this study guide has been extensively reviewed for accuracy, there may be an occasion to dispute an answer, either factually or in the interpretation of the question. Both AWWA and the author have made every effort to correct or eliminate any questions that may be confusing or ambiguous. If you do find a question that you feel is confusing or incorrect, please contact the AWWA Publishing Group.

Additionally, it is important to understand the purpose of this study guide. It does not guarantee certification. It is intended to provide the operator with an understanding of the types of math questions he or she will be presented with on a certification exam and the areas of knowledge that will be covered. AWWA highly recommends that you make use of the additional resources listed at the end of this study guide in preparing for your exam.

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This work is dedicated to my wife, Flora Zhou Giorgi, my children, Sara, Stephanie,
and Steve; my mother, Thelma Giorgi, and my father, Albert Peter Giorgi.

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PREFACE

The first edition of *Math for Water Treatment Operators* was written to provide students and operators with examples of a variety of different problems that will be encountered both on certification exams and on the job. This book is divided into four parts consisting of material associated with the first four grade levels for treatment. The problems increase in difficulty as the grade number increases.

Each problem is presented with easily followed steps and comments to facilitate understanding. One possible way to go through the math problems presented in this study guide is for you to cover the page you are working on with a piece of paper or cardboard. Then slowly move the cover down until you can read the question. Do the problem on a separate piece of paper. Uncover the worked solution and compare your method and result to the book's method and result. If your answer is the same, but your method is different, that's OK. Remember that there may be more than one way to solve a problem. If there is a certain problem that gives you trouble, try to do the problem again on another day until you completely understand it. Do similar problems that may be found in the other grades in the book. The more math problems you do, the more comfortable you will become with them.

Included after each grade level are tests to help you determine where your strengths and weaknesses are. Each test consists of randomly chosen problems from the associated problems in that chapter. The test problems are followed immediately by the solution. You can complete the problem on a separate piece of paper. After completing the test, the procedures and answers can be checked against the provided procedures and solutions.

Comprehensive CT tables are provided on a CD-ROM disk in Microsoft Excel format. Common conversion factors are included in Appendix A for reference purposes and for doing problems in this book. Appendix B is a summary of the formulas used in this book. Appendix C consists of chemistry tables that are needed for some of the problems. Appendix D includes US Environmental Protection Agency maximum contaminant level (MCL) tables for reference. And Appendix E lists the abbreviations used in this book.

Any suggestions for improving this math book including additional types of problems would be appreciated by the author. Please send your suggestions or questions to John Giorgi in care of AWWA, 6666 Quincy Avenue, Denver, CO 80235-3098.



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INTRODUCTION

SIGNIFICANT FIGURES

When you see an answer to a mathematical problem, laboratory test result, or other measured value, do you ever wonder how accurate it is? An answer's accuracy is based on the accuracy of the values used to determine the answer; the accuracy of a laboratory result depends on the precision of the measuring instruments, and even the laboratory analyst.

The following discussion explains how to determine the number of significant figures or digits an answer to any particular problem should have, i.e., how many decimal places, if any, should the answer have.

The number 30.03 has four significant figures, and the number 33,000 has only two. Why is this so? The number 30.03 has been measured to the hundredth place so the zeroes that are straddled by the threes are significant. In fact, all figures to the left of a decimal point are significant (e.g., 7.000 has four significant figures). The second number, 33,000 has only two significant figures because the zeroes are only placeholders and are thus not significant. (See the following exercise on significant figures.)

“Rounding Off”

“Rounding off” numbers is simply the dropping of figures starting on the right until the appropriate number of significant figures remains. Let's look at the three rules and an example for each that governs the process of rounding numbers.

1. When a figure less than 5 is dropped, the next figure to the left remains unchanged. Thus, the number 11.24 becomes 11.2 when the 4 is dropped.
2. When the figure is greater than 5, that number is dropped and the number to the left is increased by 1. Thus, 11.26 will become 11.3.
3. When the figure that needs to be dropped is a 5, round to the nearest even number. This prevents rounding bias. Thus, 11.35 becomes 11.4 and 46.25 becomes 46.2.



The Significance or Insignificance of Zero

A zero may be a significant figure if it is a measured value, or a zero may be insignificant and serve only as a spacer for locating the decimal point. If a zero or zeroes are used to give position value to the significant figures in the number, the zero or zeroes are not significant. An example of this would be the following expression: 1.23 mm = 0.123 cm = 0.000123 m = 0.00000123 km. The zeroes are insignificant and only give the significant figures, 1 2 3, a position that dictates their value.

Addition and Subtraction

When adding and subtracting, only similar units that are written to the same number of decimal places may be added or subtracted. Also, the number with the fewest number of decimal places, and not necessarily the fewest number of significant figures, places a limit on the number that the sum can justifiably carry.

For example, add the following numbers: 446 mm + 185.22 cm + 18.9 m. First, convert the quantities to similar units, which in this case is the meter (second row below). Next, choose the least accurate number, which is 18.9. It has only one number to the right of the decimal so the other two values will have to be rounded off (third row below).

$$\begin{array}{rcl}
 446 \text{ mm} & = & 0.446 \text{ m} \\
 185.22 \text{ cm} & = & 1.8522 \text{ m} \\
 18.9 \text{ m} & = & 18.9 \text{ m} \\
 & & \underline{\hspace{1.5cm}} \\
 & & 21.1 \text{ m}
 \end{array}$$

When adding numbers (including negative numbers), the rule is that the least accurate number will determine the number reported as the sum. In other words, the number of significant figures reported in the sum cannot be greater than the least significant figure in the group being added. Another example is given below in which the least accurate number, 170, dictates how the other three numbers will have to be changed before addition is done.

$$\begin{array}{rcl}
 1.023 \text{ g} & = & 1 \text{ g} \\
 23.22 \text{ g} & = & 23 \text{ g} \\
 170 \text{ g} & = & 170 \text{ g} \\
 \underline{1.008 \text{ g}} & = & \underline{1 \text{ g}} \\
 195.251 \text{ g} & & 195 \text{ g}
 \end{array}$$

However, you cannot report either of these values. The third value, 170 g, has two significant numbers, while all the others have four. The limiting factor is this third value, 170 g. The number 195 has three significant figures and, thus, cannot be used either. The answer must be reported as 200 g even though this looks wrong because it only has one significant figure!

Multiplication and Division

When multiplying or dividing, the number that has the fewest significant figures will dictate how the answer will be written. Suppose we have to multiply two numbers: $(23.88)(7.2) = 171.936$. The first number has four significant figures, while the second has only two. The answer should only be written with two significant figures, as 170, because one of the numbers, 7.2, has only two significant figures. In both multiplication and division, “rounding off” never should be done before the mathematical exercise. Only the result should be appropriately “rounded off.”

In the following exercise, give the number of significant figures from each of the values below:

VALUE	ANSWER
a. 8.34 lb/gal	3
b. 0.04 ntu	1
c. 23.06 mgd	4
d. 5 1-ton chlorine containers	infinite
e. 5.50 mg/L	3
f. 0.00000254	3
g. 50,000 tons	1
h. 6.023×10^{23} (the number of atoms in a mol, Avogadro’s number)	4
i. 43,560 ft ³ /acre-ft	infinite
j. 340 m	2
k. 5.01 g	3
l. 1,200,050 gal	6
m. 1,000,000/M	infinite
n. 1,440 min/d	infinite
o. 7.481 gal/ft ³	4
p. 86,400 s/d	infinite

ROUNDING IN THIS BOOK

The problems in this book are done in steps so you can see each operation visually, which facilitates understanding. In so doing, a certain amount of “pre-rounding” has to occur, otherwise the numbers continue, in most cases, to absurdity. This “pre-rounding” was done, as much as possible, so that the final answer would not be affected.

SET-UP OF PROBLEMS IN THIS BOOK

Note that many of the same types of problems have the equations written each time and that the units are written throughout each problem. This is done to help you form a good habit of writing down the equations and units. This habit should be carried over to taking certification tests. In some cases, partial credit will be given for a correctly written equation. When the units are written down, it will not only help you set up the problem correctly by seeing how the units will cancel, but will also make it easier for the person correcting the test to see your intent and also correct the problems.

Pi (π)

The number used for pi (π) will be 3.14 throughout this book.

DERIVATION OF THE NUMBER 0.785

The number 0.785 is used extensively in this book in conjunction with the diameter squared. Examples include determination of the area of a circle or the volume of a tank. The same answer can be achieved using πr^2 , where “r” equals the radius. But how was this number, 0.785, derived?

The following applies:

1. $(0.785)(\text{Diameter})^2 = \pi r^2$
2. $\text{Diameter}^2 = 4r^2$

Assume x is this number (0.785) and is not yet known. We know some number, x , times the diameter squared equals π times the radius squared. The equation is:

$$x(\text{Diameter})^2 = \pi r^2$$

From 1 above and substituting x for (0.785),
substitute $4r^2$ for Diameter^2 from 2 above:

$$x(4r^2) = \pi r^2$$

Solve for x ,

$$x = \frac{\pi r^2}{4r^2} = \frac{\pi}{4}$$

Substitute 3.14 for π and solve:

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

Thus, x is equal to 0.785, which is what we wanted to prove.

Most water treatment operators like to use $(0.785)(\text{Diameter})^2$, while engineers and scientists like to use πr^2 . Because both will be encountered, it is advisable to know both methods.

CHAPTER

1

WATER TREATMENT

Grade 1

Students preparing for grade 2 through grade 4 water treatment certification tests should also understand these problems.

CONVERSION PROBLEMS

1. How many pounds are there in 1 ft³ of water?

$$(8.34 \text{ lb/gal})(7.48 \text{ gal/ft}^3) = 62.3832 \text{ lb/ft}^3, \text{ round to } \mathbf{62.4 \text{ lb/ft}^3}$$

2. How much does exactly 100 gal of water weigh?

The equation is:

$$(\text{Number of gal}) \frac{(8.34 \text{ lb})}{\text{gal}} = \text{number of pounds}$$

$$(100 \text{ gal}) \frac{(8.34 \text{ lb})}{\text{gal}} = \mathbf{834 \text{ lb}}$$

Note: In this case 100 gal is not a measurement, but an exact amount. It therefore has an infinite number of significant figures. The limiting factor in this problem is 8.34 lb/gal (three significant figures).

3. Convert 8.2 ft³/s to gallons per minute.

$$(8.2 \text{ ft}^3/\text{s})(60 \text{ s/min})(7.48 \text{ gal/ft}^3) = 3,680 \text{ gpm, round to } \mathbf{3,700 \text{ gpm}}$$

4. How many gallons are there in 82 ft³?

$$\frac{(7.48 \text{ gal})}{1 \text{ ft}^3} (82 \text{ ft}^3) = 613.36 \text{ gal, round to } \mathbf{610 \text{ gal}}$$

5. Convert 2,445 gal to cubic feet.

$$(2,445 \text{ gal}) \frac{(1 \text{ ft}^3)}{7.48 \text{ gal}} = 326.87 \text{ ft}^3, \text{ round to } \mathbf{327 \text{ ft}^3}$$

Note: The limiting significant figure is 7.48 gal.

6. How much does 725 gal of water weigh in pounds?

$$(725 \text{ gal}) \frac{(8.34 \text{ lb})}{\text{gal}} = 6,046.5 \text{ lb, round to } \mathbf{6,050 \text{ lb}}$$

7. Convert 5.1 mgd to cubic feet per second.

$$(5.1 \text{ mgd}) \frac{(1,000,000 \text{ gal})}{1 \text{ mil gal}} \frac{(1 \text{ ft}^3)}{7.48 \text{ gal}} \frac{(1 \text{ d})}{1,440 \text{ min}} \frac{(1 \text{ min})}{60 \text{ s}} = \mathbf{7.9 \text{ ft}^3/\text{s}}$$

8. Convert 15.0 acre-ft to cubic feet.

The equation is:

(Number of acre-ft) (43,560 ft³/acre-ft)

$$(15.0 \text{ acre-ft})(43,560 \text{ ft}^3/\text{acre-ft}) = 653,400 \text{ ft}^3, \text{ round to } \mathbf{653,000 \text{ ft}^3}$$

9. Convert 4,078,611 ft³ to acre-feet.

$$\frac{4,078,611 \text{ ft}^3}{43,560 \text{ ft}^3/\text{acre-ft}} = \mathbf{93.63202 \text{ acre-ft}}$$

10. Convert 11.9 mgd to cubic feet per second.

$$(11.9 \text{ mgd}) \frac{(1,000,000 \text{ gal})}{1 \text{ mil gal}} \frac{(1 \text{ ft}^3)}{7.48 \text{ gal}} \frac{(1 \text{ d})}{1,440 \text{ min}} \frac{(1 \text{ min})}{60 \text{ s}} = \mathbf{18.4 \text{ ft}^3/\text{s}}$$

11. Convert 5.6 ft³/s to gallons per minute.

$$(5.6 \text{ ft}^3/\text{s})(60 \text{ s/min})(7.48 \text{ gal/ft}^3) = 2,513.3 \text{ gpm, round to } \mathbf{2,500 \text{ gpm}}$$

12. Convert 3.2 ft³/s to million gallons per day.

$$\frac{(3.2 \text{ ft}^3)}{\text{s}} \frac{(60 \text{ s})}{\text{min}} \frac{(1,440 \text{ min})}{\text{day}} \frac{(7.48 \text{ gal})}{\text{ft}^3} \frac{(1 \text{ mil gal})}{1,000,000 \text{ gal}} = \mathbf{2.1 \text{ mgd}}$$

13. How many million gallons are there in 22 acre-ft?

You can do the problem in one step as follows:

$$(22 \text{ acre-ft})(43,560 \text{ ft}^3/\text{acre-ft})(7.48 \text{ gal}/\text{ft}^3)(1 \text{ M}/1,000,000) = \mathbf{7.2 \text{ mil gal}}$$

14. How many million gallons are there in 43,000 acre-ft?

$$(43,000 \text{ acre-ft})(43,560 \text{ ft}^3/\text{acre-ft})(7.48 \text{ gal}/\text{ft}^3)(1 \text{ M}/1,000,000) = \mathbf{14,000 \text{ mil gal}}$$

Write down all the units so you can see which units cancel each other out.

TEMPERATURE CONVERSION PROBLEMS

15. Convert 45°F to degrees Celsius.

The equation for Celsius is:

$$\begin{aligned}\text{°C} &= \frac{5}{9}(\text{°F} - 32) \\ \text{°C} &= \frac{5}{9}(45 - 32) = \frac{5}{9}(13) = \mathbf{7.2\text{°C}}\end{aligned}$$

16. Convert 350°C to degrees Fahrenheit.

The equation for Fahrenheit is:

$$\begin{aligned}\text{°F} &= \left(\frac{9}{5}\right)\text{°C} + 32 \text{ or use } \text{F} = 1.8\text{°C} + 32\text{°F} \\ \text{°F} &= \left(\frac{9}{5}\right)350 + 32 = 662\text{°F, round to } \mathbf{660\text{°F}}\end{aligned}$$

17. Convert 75°F to degrees Celsius.

The equation for Celsius is:

$$\text{°C} = \frac{5}{9}(75 - 32) = \frac{5}{9}(43) = \mathbf{24\text{°C}}$$

PERCENT AND PARTS PER MILLION CONVERSION PROBLEMS

18. Convert a solution that has 80,147 ppm to percent.

$$\begin{aligned} &\text{A 1\% solution} = 10,000 \text{ ppm or } 10,000 \text{ mg/L} \\ &\frac{80,147 \text{ ppm}}{10,000 \text{ ppm/1\%}} = \mathbf{8.0147\% \text{ solution}} \end{aligned}$$

19. An alternative way to convert 80,147 ppm to percent is:

$$\frac{80,147 \text{ ppm} \times 100\%}{1,000,000/1\text{M}} = \mathbf{8.0147\% \text{ solution}}$$

20. A solution was found to be 1.3% alum. How many milligrams per liter of alum are in the solution?

By setting up a ratio, and knowing that a 1% solution has 10,000 mg/L, a 1.3% solution will have:

$$\begin{aligned} &\frac{10,000 \text{ mg/L}}{1\%} = \frac{x}{1.3\%} \\ &\frac{(1.3\%)(10,000 \text{ mg/L})}{1\%} = \mathbf{13,000 \text{ mg/L alum}} \end{aligned}$$

PERCENT CALCULATIONS

21. If 238 is 58%, what is 100%?

Writing a ratio can solve this problem.

$$238/58\% = x/100\% \quad x = \frac{(100\%)(238)}{58\%} = 410.3, \text{ round to } \mathbf{410}$$

An easier way to solve the problem is to know that the number for 100% must be larger than 238. If we divide by the decimal for 58%, we get the same answer, and it is a little faster to solve.

$$x = 238/0.58 = \mathbf{410}$$

22. If 154 is 100%, what is 72%?

We multiply 154 by 72%/100% because we know the number has to be smaller than 154.

$$x = (154)(72\%/100\%) = 110.9, \text{ round to } \mathbf{111}$$

23. What is the percent removal across a settling basin if the influent is 24.3 ntu and the effluent is 1.45 ntu?

The equation is:

$$\text{Percent ntu removal} = \frac{\text{Influent ntu} - \text{Effluent ntu}}{\text{Influent ntu}} \times 100\% \text{ or } \frac{\text{In} - \text{Out}}{\text{In}} \times 100\%$$

$$\text{Percent ntu removal} = \frac{(24.3 \text{ ntu} - 1.45 \text{ ntu})}{24.3 \text{ ntu}} \times 100\% = \frac{22.85 \text{ ntu}}{24.3 \text{ ntu}} \times 100\%$$

Remember: Always perform addition or subtraction within parenthesis before multiplication or division.

$$\text{Percent ntu removal} = 0.940 \times 100 = \mathbf{94.0\% \text{ removal of ntu}}$$

- 24. If 0.5 lb of soda ash are mixed into 1 gal of water, what is the percent of soda ash in the slurry?**

The following applies: 1 gal of water = 8.34 lb

$$\begin{aligned}\text{Percent soda ash} &= \frac{(0.5 \text{ lb})(100\%)}{0.5 \text{ lb} + 8.34 \text{ lb}} = \frac{(0.5 \text{ lb})(100\%)}{8.84 \text{ lb}} \\ &= 5.7\% \text{ slurry, round to } \mathbf{6\% \text{ soda ash slurry}}\end{aligned}$$

AVERAGE CALCULATIONS

- 25. What is the average in pounds per day for chlorine used given the following data?**

Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
74	78	81	84	77	73	70

The equation is:

$$\begin{aligned}\text{Average Cl}_2 \text{ used, lb/d} &= \frac{\text{Sum of Cl}_2 \text{ used each day, lb}}{\text{Total time, d}} \\ \text{Average Cl}_2 \text{ used, lb/d} &= \frac{74 + 78 + 81 + 84 + 77 + 73 + 70}{7 \text{ d}} \\ &= 76.7 \text{ lb/d Cl}_2 \text{ round to } \mathbf{77 \text{ lb/d Cl}_2}\end{aligned}$$

26. What is the average number of pounds of lime used per day given the following data? All measured values were to the nearest pound.

Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
458	523	491	503	478	471	460

The equation is:

$$\text{Average lime used, lb/d} = \frac{\text{Sum of lime used each day, lb}}{\text{Total time, d}}$$

$$\begin{aligned}\text{Average lime used, lb/d} &= \frac{458 + 523 + 491 + 503 + 478 + 471 + 460}{7 \text{ d}} \\ &= 483 \text{ lb/d lime}\end{aligned}$$

AREA PROBLEMS

27. What is the area of a basin that is 225 ft long and 42 ft wide?

The equation for a rectangular area is:

$$\text{Area} = (\text{Length})(\text{Width})$$

$$\text{Area} = (225 \text{ ft})(42 \text{ ft}) = 9,450 \text{ ft}^2, \text{ round to } 9,500 \text{ ft}^2$$

28. What is the area of a circular pond if it has a diameter of 224 ft?

The equation is:

$$(\text{Area})(\pi r^2), \text{ where } \pi = 3.14$$

First, find the radius.

$$\text{Radius} = \text{Diameter}/2 = 224/2 = 112$$

$$\text{Area of tank} = (3.14)(112 \text{ ft})(112 \text{ ft}) = 39,388.16 \text{ ft}^2, \text{ round to } \mathbf{39,400 \text{ ft}^2}$$

29. What is the diameter of a tank if the surface area is 5,200 ft²?

The equation is:

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

Solve for the diameter by rearranging the equation as shown.

$$\text{Diameter}^2 = \frac{\text{Area}}{0.785} = \frac{5,200 \text{ ft}^2}{0.785} = 6,624 \text{ ft}^2$$

Then, take the square root of 6,624 ft².

$$\text{Diameter} = 81.38 \text{ ft, round to } \mathbf{81 \text{ ft in diameter}}$$

30. What is the area of a circular reservoir if it has a diameter of 680 ft?

The equation is:

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

$$\text{Area of tank} = (0.785)(680 \text{ ft})(680 \text{ ft}) = 362,984 \text{ ft}^2, \text{ round to } \mathbf{360,000 \text{ ft}^2}$$

31. If the surface area of a rectangular drying bed is 18,125 ft² and one side measures 60.0 ft, what is the length of the other side?

The equation is:

$$\text{Area} = (\text{Length})(\text{Width})$$

$$\text{Length, ft} = \frac{\text{Area of } 18,125 \text{ ft}^2}{(60.0 \text{ ft})} = 302.08 \text{ ft, round to } \mathbf{302 \text{ ft}}$$

CIRCUMFERENCE PROBLEMS

32. What is the circumference of a tank that is 100 ft in diameter as measured to the nearest foot?

The equation is:

$$\text{Circumference} = \pi(\text{Diameter})$$

$$\text{Circumference} = (3.14)(100 \text{ ft}) = \mathbf{314 \text{ ft}}$$

33. What is the circumference of a clarifier if the radius is 28 ft?

$$\text{Circumference} = 2\pi(\text{radius}) \text{ or } 2\pi r$$

$$\text{Circumference} = 2(3.14)(28 \text{ ft}) = 175.84 \text{ ft, round to } \mathbf{180 \text{ ft}}$$

VOLUME PROBLEMS

- 34. What is the number of cubic feet in a sedimentation tank that is 340 ft long, 28 ft wide, and 7.5 ft deep?**

The volume equation for a rectangular basin is:

$$\text{Volume} = (\text{Length})(\text{Width})(\text{Depth})$$

$$\text{Volume} = (L)(W)(D) = (340 \text{ ft})(28 \text{ ft})(7.5 \text{ ft}) = 71,400 \text{ ft}^3, \text{ round to } \mathbf{71,000 \text{ ft}^3}$$

- 35. A circular tank has a radius of 16 ft and is 23.5 ft high at the spill point. What is the capacity of the tank in cubic feet?**

The volume formula for a circular tank is:

$$\text{Volume} = \pi r^2 (\text{Height}), \text{ where } r \text{ is the radius.}$$

$$\text{Volume of tank in cubic feet} = 3.14(16 \text{ ft})(16 \text{ ft})(23.5 \text{ ft}) = 18,890 \text{ ft}^3, \text{ round to } \mathbf{19,000 \text{ ft}^3}$$

- 36. Calculate the volume in cubic feet for a 14.0-in. diameter pipeline that is 1,228 ft long.**

First, convert the diameter to feet.

$$(14.0 \text{ in.}) \frac{(1 \text{ ft})}{12 \text{ in.}} = 1.167 \text{ ft (diameter)}$$

Then, convert the diameter to the radius.

$$\text{Radius} = \text{Diameter}/2 = 1.167 \text{ ft}/2 = 0.5835 \text{ ft (radius)}$$

The formula for the volume of a pipe in cubic feet is:

$$\pi r^2 (\text{Length}) \text{ or } (0.785)(\text{Diameter})^2 (\text{Length})$$

Using the first equation, the volume = $(3.14)(0.5835 \text{ ft})(0.5835 \text{ ft})(1,228 \text{ ft})$

$$\text{Volume, ft}^3 = 1,312.8 \text{ ft}^3, \text{ round to } \mathbf{1,310 \text{ ft}^3}$$

Using the second equation, the volume = $(0.785)(1.167 \text{ ft})(1.167 \text{ ft})(1,228 \text{ ft})$

$$\text{Volume, ft}^3 = 1,312.8 \text{ ft}^3, \text{ round to } \mathbf{1,310 \text{ ft}^3}$$

37. How many gallons would be in the pipe for the problem above?

$$(1,310 \text{ ft}^3)(7.48 \text{ gal/ ft}^3) = 9,799 \text{ gal, round to } \mathbf{9,800 \text{ gal}}$$

38. What is the volume of a conical tank, in cubic feet, that has a radius of 10.0 ft and a height of 17 ft?

The equation is:

$$\text{Volume, ft}^3 = \mathbf{1/3\pi r^2(\text{Height or Depth})}$$

$$\text{Volume, ft}^3 = 1/3(3.14)(10.0 \text{ ft})(10.0 \text{ ft})(17 \text{ ft}) = 1,779 \text{ ft}^3, \text{ round to } \mathbf{1,800 \text{ ft}^3}$$

- 39. Calculate the volume in cubic feet for a 16-in. diameter pipeline that is 1,850 ft long.**

First, convert the diameter to feet.

$$(16 \text{ in.}) \frac{(1 \text{ ft})}{12 \text{ in.}} = 1.33 \text{ ft (Diameter)}$$

The equation is:

$$\text{Volume, ft}^3 = (0.785)(\text{Diameter})^2(\text{Length})$$

$$\text{Volume, ft}^3 = (0.785)(1.33 \text{ ft})(1.33 \text{ ft})(1,850 \text{ ft})$$

$$\text{Volume, ft}^3 = 2,569 \text{ ft}^3, \text{ round to } \mathbf{2,600 \text{ ft}^3}$$

- 40. Determine the volume in cubic feet for a pipe with a diameter of 1.5 ft and a length of 1.75 mi.**

First, determine the number of feet in 1.75 mi.

$$(5,280 \text{ ft/mi})(1.75 \text{ mi}) = 9,240 \text{ ft}$$

$$\text{Volume, ft}^3 = (0.785)(1.5 \text{ ft})(1.5 \text{ ft})(9,240 \text{ ft}) = 16,320.15 \text{ ft}^3, \text{ round to } \mathbf{16,000 \text{ ft}^3}$$

- 41. A tank is conical at the bottom and cylindrical at the top. If the diameter of the cylinder is 18 ft with a depth of 32 ft and the cone depth is 12 ft, what is the approximate volume of the tank in cubic feet and gallons?**

First, find the volume of the cone in ft³.

$$\text{Volume, ft}^3 = 1/3\pi r^2(\text{Depth})$$

where the radius = Diameter/2 = 18 ft/2 = 9.0 ft

$$\text{Volume, ft}^3 = 1/3(3.14)(9.0 \text{ ft})(9.0 \text{ ft})(12 \text{ ft}) = 1,017.36 \text{ ft}^3$$

Next, find the volume of the cylindrical part of the tank.

$$\text{Volume, ft}^3 = \pi r^2(\text{Depth}) = (3.14)(9.0 \text{ ft})(9.0 \text{ ft})(32 \text{ ft}) = 8,138.88 \text{ ft}^3$$

Then, add the two volumes for the answer.

$$\text{Total volume, ft}^3 = 1,017.36 \text{ ft}^3 + 8,138.88 \text{ ft}^3 = 9,156.24 \text{ ft}^3, \text{ round to } \mathbf{9,200 \text{ ft}^3}$$

To find the number of gallons, multiply the total number of cubic feet by 7.48 gal/ft³.

$$(9,156.24 \text{ ft}^3)(7.48 \text{ gal/ft}^3) = 68,488.68 \text{ gal, round to } \mathbf{68,000 \text{ gal}}$$

DETENTION TIME CALCULATIONS

- 42. Calculate the detention time in hours for the following portion of a treatment plant: Five flocculation basins each 50.1 ft by 18 ft with an average water depth of 11.5 ft. A sedimentation (sed) basin that is 322 ft long, 75 ft wide, and has an average water depth of 10.0 ft. The flow through these basins is 15.6 mgd.**

First, determine the number of gallons in the five flocculation basins and the sed basin.

The equation is:

$$\text{Volume, gal} = (\text{Length})(\text{Width})(\text{Depth})(7.48 \text{ gal/ft}^3)(5 \text{ basins})$$

$$\text{Volume, gal in floc basins} = (50.1 \text{ ft})(18 \text{ ft})(11.5 \text{ ft})(7.48 \text{ gal/ft}^3)(5 \text{ basins}) = 387,864 \text{ gal}$$

$$\text{Volume, gal in sed basin} = (322 \text{ ft})(75 \text{ ft})(10.0 \text{ ft})(7.48 \text{ gal/ft}^3) = \frac{1,806,420 \text{ gal}}{2,194,284 \text{ gal}}$$

Next, convert million gallons per day to gallons per hour.

$$(15.6 \text{ mgd})(1 \text{ d}/24 \text{ hr})(1,000,000/1 \text{ M}) = 650,000 \text{ gph}$$

Write the equation with units asked for in the question.

$$\text{Detention time, hr} = \frac{\text{Volume, gal}}{\text{Flow rate, gph}}$$

$$\text{Detention time, hr} = \frac{2,194,284 \text{ gal}}{650,000 \text{ gph}} = 3.38 \text{ hr, round to } \mathbf{3.4 \text{ hr}}$$

Detention times are theoretical because basins begin to fill with settled floc and other debris and the probability that there is some short-circuiting.

43. Find the detention time in hours for a clarifier that has a diameter of 160.0 ft, a water depth of 10.25 ft, and a flow rate of 3.86 mgd.

First, determine the volume in gallons for the clarifier.

$$\text{Volume, gal} = (0.785)(\text{Diameter})^2(\text{Depth})(7.48 \text{ gal/ft}^3)$$

$$\text{Volume, gal} = (0.785)(160.0 \text{ ft})(160.0 \text{ ft})(10.25 \text{ ft})(7.48 \text{ gal/ft}^3) = 1,540,760 \text{ gal}$$

Then, convert million gallons per day to gallons per hour, because detention time is asked for in hours.

$$(3.86 \text{ mgd})(1,000,000/1 \text{ M})(1 \text{ d}/24 \text{ hr}) = 160,833 \text{ gph}$$

The equation is:

$$\text{Detention time, hr} = \frac{\text{Volume, gal}}{\text{Flow rate, gph}}$$

$$\text{Detention time, hr} = \frac{1,540,760 \text{ gal}}{160,833 \text{ gph}} = 9.58 \text{ hr}$$

PRESSURE PROBLEMS

44. What is the psi at the bottom of a tank if the water level is 24.3 ft deep?

The equation is:

$$\text{psi} = \frac{\text{Depth, ft}}{2.31 \text{ ft/psi}}$$

$$\text{psi} = \frac{24.3 \text{ ft}}{2.31 \text{ ft/psi}} = 10.5 \text{ psi}$$

45. What is the depth of water in a lake if the psi is 40.7?

The equation is:

$$\text{psi} = \frac{\text{Depth, ft}}{2.31 \text{ ft/psi}}$$

Rearrange and solve.

$$\text{Depth, ft} = (40.7 \text{ psi})(2.31 \text{ ft/psi}) = \mathbf{94.0 \text{ ft deep}}$$

46. If the water depth in a reservoir is 13.06 ft, what is the pressure at 12 ft below the surface in pounds per square foot?

The equation using pressure in pounds per square foot is:

$$\text{Pressure, lb/ft}^2 = (\text{Depth})(\text{Density, } 62.4 \text{ lb/ft}^3)$$

$$\text{Pressure} = (12 \text{ ft})(62.4 \text{ lb/ft}^3) = 748.8 \text{ lb/ft}^2, \text{ round to } \mathbf{750 \text{ lb/ft}^2}$$

DENSITY CALCULATIONS

The density of a substance is the amount of mass for a given volume.

47. What is the density in pounds per gallon of a 1.000-L solution that weighs 2.29 lb?

First, convert milliliters to gallons.

$$(1.000 \text{ L})(1 \text{ gal}/3.785 \text{ L}) = 0.2642 \text{ gal}$$

The equation is:

$$\text{Density} = \text{Mass/Volume}$$

$$\text{Density of solution} = 2.29 \text{ lb}/0.2642 \text{ gal} = \mathbf{8.67 \text{ lb/gal}}$$

48. A substance weighs 378 g and occupies a space of 48 cm³. What is its density in grams per cubic centimeter?

The equation is:

$$\text{Density} = \text{Mass/Volume}$$

$$\text{Density} = 378 \text{ g}/48 \text{ cm}^3 = 7.9 \text{ g/cm}^3$$

49. Find the density of a solution in grams per cubic centimeter if it weighs 9.50 lb/gal.

$$\text{Number of g/cm}^3 = (\text{Number of lb/gal})(454 \text{ g/1 lb})(1 \text{ gal}/3,785 \text{ cm}^3)$$

$$\text{Number of g/cm}^3 = (9.50 \text{ lb/gal})(454 \text{ g/1 lb})(1 \text{ gal}/3,785 \text{ cm}^3) = 1.14 \text{ g/cm}^3$$

50. The density of an unknown substance is 2.14 g/cm³. How much space would this substance occupy in cubic centimeters if it weighed 3.3 lb?

First, convert the number of pounds to grams.

$$\text{Number of g} = (\text{Number of lb})(454 \text{ g/1 lb})$$

Substituting:

$$\text{Number of g} = (3.3 \text{ lb})(454 \text{ g/1 lb}) = 1,498.2 \text{ g}$$

We know that 2.15 g of the substance occupies 1 cm³ by knowing its density. To get the space 1,498.2 g occupies, divide by the density.

$$\text{Space occupied by substance} = \frac{1,498.2 \text{ g}}{2.14 \text{ g/cm}^3} = 700 \text{ cm}^3$$

- 51. The density of an unknown substance is 1.87 g/cm³. How much space would this substance occupy in cubic centimeters if it weighed 25 lb?**

First, convert the number of pounds to grams.

$$\text{Number of g} = (\text{Number of lb})(454 \text{ g/1 lb})$$

Substituting:

$$\text{Number of g} = (25 \text{ lb})(454 \text{ g/1 lb}) = 11,350 \text{ g}$$

We know that 1.87 g of the substance occupies 1 cm³ by knowing its density. To get the space 11,350 g occupies, divide by the density.

$$\text{Space occupied by substance} = \frac{11,350 \text{ g}}{1.87 \text{ g/cm}^3} = 6,069.5 \text{ cm}^3, \text{ round to } \mathbf{6,100 \text{ cm}^3}$$

- 52. The specific gravity (sp gr) of a liquid solution is 1.24. How many pounds will 1 ft³ weigh?**

Rearranging the above equation:

$$\text{Pounds per ft}^3 = (\text{Specific gravity})(62.4 \text{ lb/ft}^3)$$

$$\begin{aligned} \text{Pounds per gallon of liquid solution} &= (1.24)(62.4 \text{ lb/ft}^3) \\ &= \mathbf{77.4 \text{ lb for 1 ft}^3 \text{ of the liquid solution}} \end{aligned}$$

SPECIFIC GRAVITY OF LIQUIDS

Specific gravity compares the density of one substance to another. Water is the standard for liquids.

53. The density of an unknown liquid is 56.4 lb/ft³. What is the specific gravity of the liquid?

Water has a density of 62.4 lb/ft³. Divide the density of the unknown by the density of water.

The equation is:

Specific gravity = Density of substance/Density of water

$$\text{Specific gravity of unknown substance} = \frac{56.4 \text{ lb/ft}^3}{62.4 \text{ lb/ft}^3} = \mathbf{0.904 \text{ sp gr}}$$

54. What is the specific gravity for a solution that weighs 10.18 lb/gal?

The density of water can also be expressed as pounds per gallon, or 8.34 lb/gal.

$$\text{Specific gravity} = \frac{10.18 \text{ lb/gal}}{8.34 \text{ lb/gal}} = \mathbf{1.22 \text{ sp gr}}$$

FLOW PROBLEMS

- 55. What is the velocity of flow in feet per second for a 6-in. diameter pipe if it delivers 275 gpm?**

First, convert the number of gallons per minute to cubic feet per second.

$$\text{Number of ft}^3/\text{s} = \frac{275 \text{ gpm}}{(7.48 \text{ gal/ft}^3)(60 \text{ s/min})} = 0.613 \text{ ft}^3/\text{s}$$

Next, convert the diameter from inches to feet.

$$\text{Number of ft} = (6 \text{ in.})(1 \text{ ft}/12 \text{ in.}) = 0.5 \text{ ft}$$

The equation is:

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

where the area = $(0.785)(\text{Diameter})^2$

$$0.613 \text{ ft}^3/\text{s} = (0.785)(0.5)(0.5)(\text{Velocity, ft/s})$$

Rearrange and solve for the flow in feet per second.

$$\text{Flow, ft/s} = \frac{0.613 \text{ ft}^3/\text{s}}{(0.785)(0.5)(0.5)} = 3.12 \text{ ft/s, round to } \mathbf{3 \text{ ft/s}}$$

- 56. Water is flowing through a channel that is 6.0 ft wide and 3.0 ft deep. If the flow is 28.0 ft³/s, what is the velocity of the water?**

The equation is:

$$\mathbf{Q \text{ (Flow)} = (\text{Area})(\text{Velocity})}$$

Substitute known parameters.

$$28.0 \text{ ft}^3/\text{s} = (6.0 \text{ ft})(3.0 \text{ ft})(\text{Velocity})$$

Rearrange and solve for velocity.

$$\text{Velocity} = \frac{28.0 \text{ ft}^3/\text{s}}{(6.0 \text{ ft})(3.0 \text{ ft})} = \mathbf{1.6 \text{ ft/s}}$$

CALCULATIONS OF CHLORINE DOSE, DEMAND, AND RESIDUAL

57. If the chlorine residual is 0.8 mg/L and the chlorine demand is 2.8 mg/L, what is the chlorine dose?

The equation is:

$$\text{Chlorine dose} = \text{Chlorine demand} + \text{Chlorine residual}$$

$$\text{Chlorine dose} = 2.8 \text{ mg/L} + 0.8 \text{ mg/L} = \mathbf{3.6 \text{ mg/L}}$$

58. If the chlorine dose is 3.95 mg/L and the chlorine demand is 2.43 mg/L, what is the chlorine residual?

The equation is:

$$\text{Chlorine dose} = \text{Chlorine demand} + \text{Chlorine residual}$$

Rearrange and solve for chlorine residual.

$$\text{Chlorine residual} = \text{Chlorine dose} - \text{Chlorine demand}$$

$$\text{Chlorine residual} = 3.95 \text{ mg/L} - 2.43 \text{ mg/L} = \mathbf{1.52 \text{ mg/L}}$$

DOSAGE PROBLEMS

Note: For convenience, most of the dosage problems in this book do not take chlorine demand into account.

59. If the desired dose for chlorine is 2.0 mg/L, how many pounds of chlorine per day will be needed to treat 2.1 mgd?

Use the “pounds per day” formula.

$$\text{Pounds per day} = (\text{mgd})(\text{Dosage, mg/L})(8.34 \text{ lb/gal})$$

Substituting:

$$\text{Pounds per day} = (2.1 \text{ mgd})(2.0 \text{ mg/L})(8.34 \text{ lb/gal}) = \mathbf{35 \text{ lb/d of Cl}_2}$$

60. A water treatment facility is treating 8.25 mgd. If the desired dose for chlorine is 1.8 mg/L, how many pounds of chlorine per day are required?

The equation is:

$$\begin{aligned}\text{Pounds per day} &= (\text{mgd})(\text{Dosage, mg/L})(8.34 \text{ lb/gal}) \\ \text{Pounds per day} &= (8.25 \text{ mgd})(1.8 \text{ mg/L})(8.34 \text{ lb/gal}) \\ &= 123.8 \text{ lb/d, round to } \mathbf{120 \text{ lb/d of Cl}_2}\end{aligned}$$

61. A water treatment facility is treating 5.8 mgd. If the desired dose for chlorine is 1.5 mg/L, how many pounds of chlorine per day are required?

The equation is:

$$\text{Pounds per day} = (\text{mgd})(\text{Dosage, mg/L})(8.34 \text{ lb/gal})$$

Substituting:

$$\begin{aligned}\text{Pounds per day} &= (5.8 \text{ mgd})(1.5 \text{ mg/L})(8.34 \text{ lb/gal}) \\ &= 72.6 \text{ lb/d, round to } \mathbf{73 \text{ lb/d of Cl}_2}\end{aligned}$$

62. What is the chlorine dosage in milligrams per liter if 4.6 mgd is treated with 55 lb/d of chlorine?

The equation is:

$$\text{Pounds per day} = (\text{mgd})(\text{Dosage, mg/L})(8.34 \text{ lb/gal})$$

Substituting and rearranging the formula:

$$\begin{aligned}\frac{(55 \text{ lb/d})}{(4.6 \text{ mgd})(8.34 \text{ lb/gal})} &= \text{Dosage} \\ \text{Dosage, mg/L} &= \mathbf{1.4 \text{ mg/L of Cl}_2}\end{aligned}$$

63. How many pounds per day of liquid alum are used if the flow rate is 12.7 mgd and the dosage is 8.25 mg/L? The purity of the alum is 48.0%.

Convert the percent purity to decimal form.

$$48.0\%/100\% = 0.480$$

The equation is:

$$\text{Pounds per day} = \frac{(\text{mgd})(\text{Dosage, mg/L})(8.34 \text{ lb/gal})}{\% \text{ purity}}$$

$$\text{Pounds per day, alum} = \frac{(12.7 \text{ mgd})(8.25 \text{ mg/L})(8.34 \text{ lb/gal})}{48.0\%/100\% \text{ purity}}$$

$$\text{Pounds per day, alum} = \mathbf{1,820 \text{ lb/d of alum}}$$

64. How many pounds per day of lime are being used to treat 4.5 mgd with a dosage of 7.2 mg/L? The lime is 89% pure.

The equation is:

$$\text{Pounds per day, lime} = \frac{(\text{mgd})(\text{Dosage, mg/L})(8.34 \text{ lb/gal})}{\% \text{ purity}}$$

$$\text{Pounds per day, lime} = \frac{(4.5 \text{ mgd})(7.2 \text{ mg/L})(8.34 \text{ lb/gal})}{89.0\%/100\% \text{ purity}}$$

$$= 304 \text{ lb/d, round to } \mathbf{300 \text{ lb/d of lime}}$$

65. A treatment plant is using 880 lb/d of chlorine gas. If the chlorine demand is 2.8 mg/L and the chlorine residual is 1.5 mg/L, how many million gallons per day are being treated?

First, find the total chlorine dosage.

$$\text{Total Cl}_2 \text{ dosage} = \text{Cl}_2 \text{ Demand} + \text{Cl}_2 \text{ Residual}$$

$$\text{Total Cl}_2 \text{ dosage} = 2.8 \text{ mg/L (Demand)} + 1.5 \text{ mg/L (Residual)} = 4.3 \text{ mg/L}$$

Then, use the “pounds” formula, but solve for the unknown, million gallons per day.

$$\text{Pounds per day} = (\text{mgd})(\text{Dosage})(8.34 \text{ lb/gal})$$

$$\text{Million gallons per day} = \frac{\text{lb/d}}{(\text{Dosage})(8.34 \text{ lb/gal})}$$

$$\text{Million gallons per day} = \frac{880 \text{ lb/d}}{(4.3 \text{ mg/L})(8.34 \text{ lb/gal})} = 24.5 \text{ mgd, round to } \mathbf{25 \text{ mgd}}$$

66. A plant is treating water at 72.3 mgd. If lime is being added at a rate of 1,645.94 g/min, what is the lime usage in pounds per day and the dosage in milligrams per liter?

First, find the pounds per day of lime usage.

$$\text{Pounds per day of lime} = (\text{g/min})(1,440 \text{ min/d})(1 \text{ lb}/454 \text{ g}) = \text{lb/d}$$

$$\text{Pounds per day of lime} = (1,645.94 \text{ g/min})(1,440 \text{ min/d})(1 \text{ lb}/454 \text{ g})$$

$$= \mathbf{5,220.60 \text{ lb/d of lime}}$$

Then, using the “pounds” equation, calculate the dosage in milligrams per liter by rearranging the formula and solving for dosage.

$$\text{Dosage, mg/L} = \frac{\text{lb/day}}{(\text{mdg})(8.34 \text{ lb/gal})}$$

$$\text{Dosage, mg/L} = \frac{5,220.60 \text{ lb/d}}{(72.3 \text{ mgd})(8.34 \text{ lb/gal})} = \mathbf{8.66 \text{ mg/L of lime}}$$

67. A treatment plant is treating 24.2 mgd with a 64% calcium hypochlorite solution. The dosage is 1.25 mg/L. If the flow rate is reduced to 17.8 mgd and the dosage is also reduced to 1.20 mg/L, how many pounds per day of sodium hypochlorite are needed for the new flow rate?

The equation is:

$$\text{Pounds per day} = \frac{(\text{mgd})(\text{Dosage, mg/L})(8.34 \text{ lb/gal})}{\% \text{ purity}}$$

Notice that you were given some data that was not required for answering the problem.

Substituting:

$$\text{Pounds per day of calcium hypochlorite} = \frac{(17.8 \text{ mgd})(1.20 \text{ mg/L})(8.34 \text{ lb/gal})}{64\%/100\%}$$

$$\text{Pounds per day of calcium hypochlorite} = \frac{(183.1 \text{ lb/d})}{64\%/100\%}$$

$$\begin{aligned} \text{Pounds per day of calcium hypochlorite} &= \\ 278.3 \text{ lb/d, round to } &\mathbf{278 \text{ lb/d calcium hypochlorite}} \end{aligned}$$

68. Water from a well is being treated with a 5.0% sodium hypochlorite solution. The hypochlorinator is pumping at a rate of 33.6 gpd. What is the chlorine dosage in milligrams per liter if the well is producing 325 gpm? Assume the hypochlorite solution is 8.34 lb/gal.

First, convert the production rate of the pump to million gallons per day.

$$\text{Million gallons per day} = \frac{(\text{Pumping rate})(1,440 \text{ min/d})}{1,000,000/\text{M}}$$

$$\text{Million gallons per day} = \frac{(325 \text{ gpm})(1,440 \text{ min/d})}{1,000,000/\text{M}} = 0.468 \text{ mgd}$$

Next, calculate the chlorine usage in pounds per day.

$$\text{Chlorine usage, lb/d} = \frac{(\text{Hypochlorinator flow, gpd})(\% \text{ hypochlorite})(8.34 \text{ lb/gal})}{100\%}$$

$$\text{Chlorine usage, lb/d} = \frac{(33.6 \text{ gpd})(5.0\%)(8.34 \text{ lb/gal})}{100\%} = 14.01 \text{ lb/d, round to } \mathbf{14 \text{ lb/d}}$$

Last, calculate the chlorine dosage in milligrams per liter using the “pounds” formula.

$$\text{Chlorine dosage, mg/L} = \frac{\text{Chlorine, lb/d}}{(\text{Well flow, mgd})(8.34 \text{ lb/gal})}$$

$$\text{Chlorine dosage, mg/L} = \frac{14.01 \text{ lb/d}}{(0.468 \text{ mgd})(8.34 \text{ lb/gal})} = \mathbf{3.6 \text{ mg/L}}$$

- 69. A 5-min drawdown test result showed that 120 mL of a polymer aid was being used to treat the raw water. The specific gravity of the polymer is 1.18. If the plant is treating 24 ft³/s, what is the polymer dosage in milligrams per liter?**

First, determine the number of milliliters per minute for the polymer.

$$\frac{(120 \text{ mL})}{5 \text{ min}} = 24 \text{ mL/min}$$

Next, calculate the pounds per gallon for the polymer.

$$\text{Pounds per gallon} = (\text{Specific gravity})(8.34 \text{ lb/gal})$$

$$\text{Pounds per gallon, polymer} = (1.18)(8.34 \text{ lb/gal}) = 9.84 \text{ lb/gal}$$

Then, find the number of million gallons per day.

$$(24 \text{ ft}^3/\text{s})(86,400 \text{ s/d})(7.48 \text{ gal/ft}^3)(1 \text{ M}/1,000,000) = 15.5 \text{ mgd}$$

Use the dosage equation with conversions added for convenience (dosage/conversion equation).

$$\text{Milligrams per liter, polymer} = \frac{(\text{mL/min})(1,440 \text{ min/d})(\text{lb/gal, polymer})}{(3,785 \text{ mL/gal})(\text{mgd})(8.34 \text{ lb/gal})}$$

$$\text{Milligrams per liter, polymer} = \frac{(24 \text{ mL/min})(1,440 \text{ min/d})(9.84 \text{ lb/gal})}{(3,785 \text{ mL/gal})(15.5 \text{ mgd})(8.34 \text{ lb/gal})}$$

$$= \mathbf{0.70 \text{ mg/L of polymer aid}}$$

- 70. A small tank containing 775 gal of water is to be disinfected using a sodium hypochlorite solution. If the dosage is 50.0 mg/L and the available chlorine in the solution is 5.0%, how much hypochlorite solution should be added, in ounces? Assume the sodium hypochlorite (hypo) weighs 8.92 lb/gal.**

First, solve the problem using the modified “pounds” formula.

The equation is:

$$\text{Pounds} = \frac{(\text{mil gal})(\text{Dosage, mg/L})(8.34 \text{ lb/gal})}{\% \text{ purity}}$$

Delete “day” on each side of the equation, because it is not what we’re looking for.

Next, find how many million gallons there are in 775 gal.

$$\text{Million gallons} = \frac{775 \text{ gal}}{1,000,000/\text{M}} = 0.000775 \text{ mil gal}$$

Substituting:

$$\text{Pounds of hypo} = \frac{(0.000775 \text{ mil gal})(50.0 \text{ mg/L})(8.34 \text{ lb/gal})}{5\%/100\%} = 6.46 \text{ lb}$$

Now, convert pounds to gallons.

$$\frac{6.46 \text{ lb of hypo}}{8.92 \text{ lb/gal}} = 0.72 \text{ gal}$$

Now, convert gallons to ounces.

$$\begin{aligned} \text{Number of ounces, hypo} &= (128 \text{ oz/gal})(0.72 \text{ gal}) \\ &= 92.16 \text{ oz, round to } \mathbf{92 \text{ oz of hypochlorite}} \end{aligned}$$

- 71. A 325,000-gal water tank is to be disinfected with a 61% hypochlorite solution. The dosage desired is 50.0 mg/L. How many liters of hypochlorite will be required?**

First, convert 325,000 gal to million gallons.

$$325,000 \text{ gal} = \frac{0.325 \text{ mil gal}}{1,000,000/\text{M}}$$

Next, determine the number of pounds of hypochlorite required.

The equation is:

$$\text{Pounds} = \frac{(\text{mgd})(\text{Dosage, mg/L})(8.34 \text{ lb/gal})}{\% \text{ purity}}$$

Delete “day” on each side of the equation because it is not needed.

$$\text{Pounds, hypo} = \frac{(0.325 \text{ mil gal})(50.0 \text{ mg/L})(8.34 \text{ lb/gal})}{61\%/100\%} = 222.17 \text{ lb of hypo}$$

Now, convert the number of pounds of hypo to gallons.

$$\frac{222.17 \text{ lb of hypo}}{8.34 \text{ lb/gal}} = 26.639 \text{ gal}$$

Last, convert gallons to liters.

$$(26.639 \text{ gal})(3.785 \text{ L/gal}) = 100.829 \text{ L of hypo, round to } \mathbf{100 \text{ L of hypochlorite}}$$

Note: The 8.34 lb/gal multiplier in the first step can be dropped in the “pounds” equation. However, to avoid confusion, it was retained here, thus the need for the second step.

- 72. How many milliliters per minute of cationic polymer are needed if the desired dose is 1.40 mg/L and the plant is treating 37 ft³/s? The polymer has a specific gravity of 1.20 and is 89.8% pure.**

First, convert cubic feet per second to million gallons per day.

$$\frac{(37 \text{ ft}^3/\text{s})(86,400 \text{ s/d})(7.48 \text{ gal/ft}^3)}{1,000,000/1 \text{ mil gal}} = 23.91 \text{ mgd}$$

Next, find the number of pounds per gallon for the polymer.

$$\frac{(1.20)(8.34 \text{ lb/gal})(89.8\% \text{ purity})}{100\%} = 8.99 \text{ lb/gal}$$

Next, find the number of pounds per day of polymer using the “pounds” formula.

$$\text{Pounds per day} = (\text{mgd})(\text{Dosage, mg/L})(8.34 \text{ lb/gal})$$

$$\text{Pounds per day} = (23.91 \text{ mgd})(1.40 \text{ mg/L})(8.34 \text{ lb/gal})$$

$$\text{Pounds per day} = 279.17 \text{ lb/d}$$

(continued)