Answers to Water Distribution Operator Questions

1 System Information/Components

2 Sample Questions for Level I-Answers

1. Answer: c. feet.

Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Hydraulics 3.

2. Answer: a. a map.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Glossary.

3. Answer: d. Air-and-vacuum relief valve

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 6.

4. Answer: a. cathodic protection.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

5. Answer: a. Early morning

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 5.

3 Sample Questions for Level II-Answers

1. Answer: a. pressure head.

Reference: Pumping: Fundamentals for the Water & Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company.

2. Answer: b. pump head.

Reference: Pumping: Fundamentals for the Water & Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company.

3. Answer: d. roughness that retards flow due to friction.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

4. Answer: b. Push-on joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2. 5. Answer: d. air gap, RPZ, DCVA, and VB.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry May Editor. American Water Works Association. Chapter 11.

4 Sample Questions for Level III-Answers

1. Answer: c. proportionately.

Reference: Pumping: Fundamentals for the Water & Wastewater Maintenance

Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publis Company. Chapter 3.

2. Answer: c. Arterial-loop system

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays Editor. American Water Works Association. Chapter 2.

3. Answer: a. Grid system

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays Editor. American Water Works Association. Chapter 2.

4. Answer: c. 35 psi or greater.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays Editor. American Water Works Association. Chapter 2.

5. Answer: b. Restrained joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mayse Editor. American Water Works Association. Chapter 2.

5 Sample Questions for Level IV-Answers

1. Answer: c. to increase flow.

Reference: Pumping: Fundamentals for the Water & Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publisı Company. Chapter 2.

2. Answer: a. It has the potential for both internal and external corrosion

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mayse Editor. American Water Works Association. Chapter 2.

3. Answer: c. the Hazen-Williams formula.

Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas = Pizzi, Editor. American Water Works Association. Hydraulics 5.

4. Answer: c. potential energy.

Reference: Pumps & Pumping, 9th edition. 2010. E.E. "Skeet" Arasmith, Mitch Scheele, & Kimon Zentz. ACR Publications. Lesson 1.

5. Answer: a. 1;2

Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas Pizzi, Editor. American Water Works Association. Hydraulics 4.

6 Monitor, Evaluate, and Adjust Disinfection

7 Sample Questlons for Level I-Answers

1. Answer: c. has a persistent residual.

Reference: Water Treatment, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Chapter 7.

2. Answer: b. 2.5

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 8.

3. Answer: c. Coliform test

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 3.

4. Answer: d. Use a chlorine gas detector and place it next to any area suspected of leaking

Reference: M20, Water Chlorination / Chlorination Practices and Principles, 2nd edition. 2006. American Water Works Association. Chapter 4.

5. Answer: a. a detectable level

Reference: 40 CFR 141 Subpart G: National Primary Drinking Water Regulations: Maximum Contaminant Levels and Maximum Residual Disinfectant Levels.

8 Sample Questions for Level Il-Answers

1. Answer: b. 5 to 20%

Reference: M20, Water Chlorination / Chlorination Practices and Principles, 2nd edition. 2006. American Water Works Association. Chapter 2.

2. Answer: d. somewhere in the distribution system.

Reference: M20, Water Chlorination/Chlorination Practices and Principles, 2nd edition. 2006. American Water Works Association. Chapter 6.

3. Answer: b. 25mg/L

Reference: M20, Water Chlorination/Chlorination Practices and Principles, 2nd edition. 2006. American Water Works Association. Appendix C.

4. Answer: c. Residual disinfectant concentration

Reference: National Primary Drinking Water Regulations, Subpart H - Filtration and Disinfection, $141.74 - Analytical and monitoring requirements (b)(6)(i)

5. Answer: a. a weak acid.

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 8.

9 Sample Questions for Level III-Answers

1. Answer: b. Chlorine

Reference: Water Treatment, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Chapter 7. 2. Answer: a. 4.0mg/L
Reference: M20, Water Chlorination / Chlorination Practices and Principles, 2nd edition. 2006. American Water Works Association. Chapter 3.

3. Answer: a. Clogged equipment

Reference: Water Treatment, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Chapter 7.

4. Answer: c. Organic material

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 8.

5. Answer: b. Every 4 hours

Reference: National Primary Drinking Water Regulations, Subpart H - Filtration and Disinfection, §141.74 - Analytical and monitoring requirements $(b)(5)$

10 Sample Questlons for Level IV-Answers

1. Answer: c. Nematodes

Reference: M7, Problem Organisms in Water: Identification and Treatment, 3rd edition. 2003. American Water Works Association. Chapter 5.

2. Answer: a. 0.4 to 0.5mg/L

Reference: Water Treatment, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Chapter 7.

3. Answer: d. 4.5 : 1 to 5.0 : 1

Reference: M20, Water Chlorination / Chlorination Practices and Principles, 2nd edition. 2006. American Water Works Association. Chapter 6.

4. Answer: c. sodium chlorite + chlorine at low pH values.

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 8.

5. Answer: d. Routine use of disinfectant and penetrant

Reference: M7, Problem Organisms in Water: Identification and Treatment, 3rd edition. 2003. American Water Works Association. Chapter 11.

11 Laboratory Analysis

12 Sample Questions for Level I-Answers

1. Answer: b. 6 hours.

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 10.

2. Answer: c. sodium thiosulfate.

Reference: Basic Microbiology for Drinking Water Personnel, 2nd edition. 2006. Dennis R. Hill. American Water Works Association. Chapter 4.

3. Answer: a. 100 mL.

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 12.

4. Answer: b. 15 minutes.

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 6.

5. Answer: a. Heterotrophic plate count (HPC)

Reference: National Primary Drinking Water Regulations, Subpart H - Filtration and Disinfection, §141.74 - Analytical and monitoring requirements (b)(6)(i)

13 Sample Questlons for Level II-Answers

1. Answer: a. pH

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 12.

2. Answer: a. accept an electron pair.

Reference: The Water Dictionary: A Comprehensive Reference of Water Terminology, 2nd edition. 2010. Nancy McTigue, Editor, and James M. Symons, Editor Emeritus. American Water Works Association.

3. Answer: b. Lime

Reference: Water Treatment, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. 4th edition. Chapter 4.

4. Answer: a. faucet without threads.

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 2.

5. Answer: a. DPD color comparater

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 6.

14 Sample Questions for Level Ill-Answers

1. Answer: d. concentrated nitric acid.

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 6. 2. Answer: b. Every 4 hours

Reference: National Primary Drinking Water Regulations, Subpart H - Filtration and Disinfection, §141.74 - Analytical and monitoring requirements (c)(1)

3. Answer: b. Lowest value for chlorine residual and contact time, lowest temperature, and highest pH

Reference: National Primary Drinking Water Regulations, Subpart H - Filtration and Disinfection, $141.75 - Reporting and record keeping requirements (a)(2) (i, iii, iv, v)

4. Answer: c. 0.015mg/L.

Reference: National Primary Drinking Water Regulations, Subpart I - Control of Lead and Copper, §141.80 - General requirements (c)(1)

5. Answer: c. TOC $<$ 2.0mg/L for 2 years or $<$ 1.0mg/L for 1 year

Reference: National Primary Drinking Water Regulations Subpart L-Disinfectant Residuals, Disinfectant By-products and Disinfectant By-product precursors, $141.132 - Monitoring requirements (d)(2)

15 Sample Questlons for Level IV-Answers

1. Answer: a. By taking the average of the highest and second highest concentrations Reference: National Primary Drinking Water Regulations, Subpart I - Control of Lead and Copper, $141.80 - General requirements (c)(3)(iv)

2. Answer: c. TTHM $\leq$ 0.040mg/L and HAA5 $\leq$ 0.030mg/L.

Reference: National Primary Drinking Water Regulations, Subpart L-Disinfectant Residuals, Disinfectant By-products and Disinfectant By-product Precursors, §141.132 - Monitoring requirements (b)(1)(ii), Table - Reduced monitoring frequency for TTHM and HAA5

3. Answer: a. one three-sample set per quarter

Reference: National Primary Drinking Water Regulations, Subpart L-Disinfectant Residuals, Disinfectant By-products and Disinfectant By-product Precursors, §141.132 - Monitoring requirements (b)(2)(iii)(B)

4. Answer: d. No more than 5%

Reference: National Primary Drinking Water Regulations, Subpart G - Maximum Contaminant Levels and Maximum Residual Disinfectant Levels, $141.63– Maximum contaminant levels (MCLs) for microbiological contaminants (a)(1)

5. Answer: b. develop a disinfection benchmark.

Reference: National Primary Drinking Water Regulations Subpart P - Enhanced Filtration and Disinfection-Systems Serving 10,000 or More People, $141.172 Disinfection profiling and benchmarking (c)(1)

16 Install Equipment

17 Sample Questions for Level I-Answers

1. Answer: a. 6 inches

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 7.

2. Answer: a. service line.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 6.

3. Answer: b. 3.0 feet

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

4. Answer: c. Not having the joint completely clean

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

5. Answer: c. Blowoff valve

Reference: Water Distribution System Operation and Maintenance, 5th edition. 2005. Ken Kerri. California State University - Sacramento. Page 71.

18 Sample Questions for Level II-Answers

1. Answer: c. compressed beveled gasket.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 15.

2. Answer: c. beam breakage.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

3. Answer: c. perpendicular

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

4. Answer: a. Restraining fittings

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

5. Answer: a. moisture.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 13.

19 Sample Questions for Level Ill-Answers

1. Answer: a. gate valve.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 6. 2. Answer: a. 1 to 2 inches

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 10.

3. Answer: b. By gently tapping the length of the pipe with a hammer; the pipe should ring or hum clearly

Reference: Water Distribution System Operation and Maintenance, 5th edition. 2005. Ken Kerri. California State University - Sacramento. Page 90.

4. Answer: c. 66 inches

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

5. Answer: c. the centerline of the pipe.

Reference: Water Distribution System Operation and Maintenance, 5th edition. 2005. Ken Kerri. California State University - Sacramento. Page 105.

20 Sample Questions for Level IV-Answers

1. Answer: d. 1 inch.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

2. Answer: a. $\frac{1}{32}$ inch

Reference: Pumps & Pumping, 9th edition. 2010. E.E. "Skeet" Arasmith, Mitch Scheele, & Kimon Zentz. ARC Publications. Chapter 4.

3. Answer: d. 4.0 degrees

Reference: Pumps & Pumping, 9th edition. 2010. E.E. "Skeet" Arasmith, Mitch Scheele, & Kimon Zentz. ARC Publications. Chapter 4.

4. Answer: d. downstream; pressure

Reference: Water Distribution System Operation and Maintenance, 5th edition. 2005. Ken Kerri. California State University - Sacramento. Page 121.

5. Answer: d. The relief valve will remain fully open and an air gap (atmospheric pressure) will form between the check valves, closing them both

Reference: Water Distribution System Operation and Maintenance, 5 th edition. 2005. Ken Kerri. California State University - Sacramento. Page 146.

21 Operate Equipment

22 Sample Questions for Level I-Answers

1. Answer: b. impeller.

Reference: Pumps & Pumping, 9th edition. 2010. E.E. "Skeet" Arasmith, Mitch Scheele, & Kimon Zentz. ARC Publications. Lesson 3.

2. Answer: c. Mechanical seal

Reference: Pumps & Pumping, 9th edition. 2010. E.E. “Skeet” Arasmith, Mitch Scheele, & Kimon Zentz. ARC Publications. Lesson 3.

3. Answer: c. Seals

Reference: Pumping: Fundamentals for the Water & Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 3.

4. Answer: a. Packing gland

Reference: Pumping: Fundamentals for the Water & Wastewater Maintenance

Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 4.

23 Answer: d. Stuffing box

Reference: Pumping: Fundamentals for the Water & Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 3.

24 Sample Questions for Level II-Answers

1. Answer: b. Key

Reference: Pumps & Pumping, 9th edition. 2010. E.E. "Skeet" Arasmith, Mitch Scheele, & Kimon Zentz. ARC Publications. Lesson 4.

2. Answer: c. Gate valve

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 4.

3. Answer: b. acoustic waves.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 5.

4. Answer: c. Globe valve

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 6.

5. Answer: b. Strain gauge

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 9.

25 Sample Questions for Level III-Answers

1. Answer: c. Electric and magnetic forces

Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Electricity 1.

2. Answer: a. pressure head.

Reference: Pumping: Fundamentals for the Water & Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 2.

3. Answer: b. Two stage

Reference: Pumps & Pumping, 9th edition. 2010. E.E. "Skeet" Arasmith, Mitch Scheele, & Kimon Zentz. ARC Publications. Lesson 2.

4. Answer: b. Two stages

Reference: Pumps & Pumping, 9th edition. 2010. E.E. "Skeet" Arasmith, Mitch Scheele, & Kimon Zentz. ARC Publications. Lesson 2.

5. Answer: c. Open suction piping air bleed-off valves

Reference: Pumping: Fundamentals for the Water & Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 9.

26 Sample Questions for Level IV-Answers

1. Answer: a. center of the impeller.

Reference: Pumps & Pumping, 9th edition. 2010. E.E. "Skeet" Arasmith, Mitch Scheele, & Kimon Zentz. ARC Publications. Lesson 3.

2. Answer: b. torque

Reference: Pumps & Pumping, 9th edition. 2010. E.E. "Skeet" Arasmith, Mitch Scheele, & Kimon Zentz. ARC Publications. Lesson 3.

3. Answer: c. 9,000 to $15,000$rpm

Reference: Pumping: Fundamentals for the Water & Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company.

4. Answer: a. $3,000$rpm.

Reference: Pumping: Fundamentals for the Water & Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company.

5. Answer: a. Power failure shutting down a pump suddenly

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 5.

27 Perform Malntenance

28 Sample Questions for Level I-Answers

1. Answer: d. To prevent cavitation from occurring

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 4.

2. Answer: b. Ohm

Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Electricity 2.

3. Answer: b. after one month of operation.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 4.

4. Answer: d. Once a month

Reference: Pumping: Fundamentals for the Water & Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing. Chapter 6.

5. Answer: a. air

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association.

29 Sample Questions for Level II-Answers

1. Answer: b. no further tightening can be done on the packing gland.

Reference: Pumps & Pumping, 9th edition. 2010. E.E. "Skeet" Arasmith, Mitch Scheele, & Kimon Zentz. ARC Publications. Lesson 5.

2. Answer: d. Rectifier

Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Electricity 3.

3. Answer: c. heated.

Reference: Pumps & Pumping, 9th edition. 2010. E.E. "Skeet" Arasmith, Mitch Scheele, & Kimon Zentz. ARC Publications. Lesson 4.

4. Answer: d. wear and deteriorate with normal use.

Reference: Pumps & Pumping, 9th edition. 2010. E.E. "Skeet" Arasmith, Mitch Scheele, & Kimon Zentz. ARC Publications. Lesson 5.

5. Answer: a. oil or water.

Reference: Pumps & Pumping, 9th edition. 2010. E.E. “Skeet" Arasmith, Mitch Scheele, & Kimon Zentz. ARC Publications. Lesson 10.

30 Sample Questions for Level Ill-Answers

1. Answer: b. excessive heat.

Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Electricity 3.
2. Answer: a. 5%.
Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 8.

3. Answer: c. oxidation of ammonia to nitrites then to nitrates.

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 8.

4. Answer: a. Split coupling

Reference: Pumps & Pumping, 9th edition. 2010. E.E. "Skeet" Arasmith, Mitch Scheele, & Kimon Zentz. ARC Publications. Lesson 9.

5. Answer: a. Volts = (amps)(ohms)

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 8.

31 Sample Questions for Level IV-Answers

1. Answer: c. Transmitter, transmission channel, and receiver

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 9.

2. Answer: b. 10 years; year

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 3.

3. Answer: d. 5.0 to 10.0

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 8.

4. Answer: a. digital signals.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 9.

5. Answer: b. Signal conditioners, actuators, and control elements

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 9.

32 Perform Security, Safety, and Administrative Procedures

33 Sample Questions for Level I-Answors

1. Answer: b. United States Environmental Protection Agency

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 1.

2. Answer: a. Tier I

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 1.

3. Answer: c. 24 hours.

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 4.

4. Answer: c. based on population served.

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 12.

5. Answer: b. 1.0 : 1.0

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

34 Sample Questlons for Level II-Answers

1. Answer: c. 0.080mg/L

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 1.

2. Answer: a. Tier I

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 1.

3. Answer: a. coliform samples.

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 1.

4. Answer: d. 0.30mg/L.

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 6.

5. Answer: d. Zinc orthophosphate

Reference: Water Treatment, Nicholas G. Pizzi, Editor, 4th edition. Chapter 9.

35 Sample Questions for Level III-Answers

1. Answer: c. 5%

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 1. 2. Answer: d. 10.0mg/L
Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 1.

36 Answer: d. 12 months

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 1.

4. Answer: b. clay.

Reference: The Water Dictionary: A Comprehensive Reference of Water Terminology, 2nd edition. 2010. Nancy McTigue, Editor, and James M. Symons, Editor Emeritus. American Water Works Association.

5. Answer: b. 90%

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 10.

37 Sample Questions for Level IV-Answers

1. Answer: d. A qualified third party

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 3.

2. Answer: c. 75%

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 3.

3. Answer: c. excavation.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

4. Answer: b. Ricin

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 17.

5. Answer: a. 10 ppm.

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 13.

38 Answers to Additional Distribution Operator Practice Questions

1. Answer: d. Late evening

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 5.

2. Answer: d. Sectional maps

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 16.

3. Answer: c. Flexible ball joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

4. Answer: d. friction head.

Reference: Pumping: Fundamentals for the Water and Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company.

5. Answer: c. 6 inches.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

6. Answer: a. minimize friction loss.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

7. Answer: a. Bell and spigot type

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

8. Answer: b. Thermal butt-fusion

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

9. Answer: b. Restrained joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

10. Answer: d. Flanged joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

11. Answer: d. It will be the same in all three tanks

Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Hydraulics 2.
12. Answer: b. Piezometric surface
Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Hydraulics 3.

13. Answer: d. sudden changes in direction or velocity of flow.

Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Hydraulics 5.

14. Answer: d. adequate fire flow at an appropriate pressure.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

15. Answer: c. 50 to 75 psi.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

16. Answer: c. Tensile and flexural strength

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

17. Answer: d. tensile strength.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

18. Answer: d. 2.5 inches; 4.5 inches

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 7.

19. Answer: c. Ductile iron

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 3.

20. Answer: c. Bell and spigot type

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

21. Answer: a. slightly scale forming.

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 9.

22. Answer: b. Unmetered connection for a fire protection system

Reference: The Water Dictionary: A Comprehensive Reference of Water Terminology, 2nd edition. 2010. Nancy McTigue, Editor, and James M. Symons, Editor Emeritus. American Water Works Association.

23. Answer: b. 500 to 1,000 feet to 1 inch.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 16.

24. Answer: a. 50 to 100 feet to 1 inch.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 16. 25. Answer: b. Radial flow impellers

Reference: Pumping: Fundamentals for the Water and Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 3.

26. Answer: c. Expansion joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

27. Answer: b. Rubber gasket joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

28. Answer: b. 20 psi.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

29. Answer: b. 20 psi.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 7.

30. Answer: d. Tree system

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

31. Answer: b. DC current

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 3.

32. Answer: c. inadequate distribution storage.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 3.

33. Answer: b. Head requirements

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 4.

34. Answer: b. Capacity (flow rate)

Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Hydraulics 6.

35. Answer: d. fluids in motion and at rest.

Reference: Pumping: Fundamentals for the Water and Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 2.

36. Answer: c. Flanged joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

37. Answer: d. Mechanical joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2. 38. Answer: c. 33.9 feet

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 11.

39. Answer: d. 34

Reference: Pumping: Fundamentals for the Water and Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company.

40. Answer: a. Closed

Reference: Pumps & Pumping, 9th edition. E.E. "Skeet" Arasmith, Mitch Scheele, and Kimon Zentz. ACR Publications. Lesson 1.

41. Answer: a. End suction pump

Reference: Pumps & Pumping, 9th edition. E.E. "Skeet" Arasmith, Mitch Scheele, and Kimon Zentz. ACR Publications. Lesson 2.

42. Answer: b. 2.5 to 4.0 times

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

43. Answer: c. Asbestos cement

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

44. Answer: b. Reinforced concrete

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

45. Answer: b. Ductile iron

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

46. Answer: c. Polyvinyl chloride

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

47. Answer: c. river crossings or rugged terrain.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

48. Answer: d. where flexibility is required.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

49. Answer: a. only for small lines.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

50. Answer: a. for all locations.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2. 51. Answer: a. Ball and socket joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

52. Answer: b. Push-on joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

53. Answer: d. Shouldered joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

54. Answer: d. 150+

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

55. Answer: c. Emergency storage tanks

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 3.

56. Answer: b. Needle valve

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 6.

57. Answer: d. Pinch valve

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 6.

58. Answer: c. cold climates.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 15.

59. Answer: b. thrust load.

Reference: Pumps & Pumping, 9th edition. 2010. E.E. "Skeet" Arasmith, Mitch Scheele, and Kimon Zentz. ACR Publications. Lesson 3.

60. Answer: b. 20%

Reference: Pumping: Fundamentals for the Water and Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company.

61. Answer: d. to complete a grid.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

62. Answer: a. Reinforced concrete

Reference: Water Transmission and Distribution, 4 th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

63. Answer: b. Steel

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2. 64. Answer: b. 2 to 8 inches

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

65. Answer: c. modeling and analysis.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 16.

66. Answer: d. Base data

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 16.

67. Answer: c. Calcium hypochlorite

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 8.

68. Answer: b. 6 hours

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 3.

69. Answer: d. 24 hours

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 3.

70. Answer: b. 0.2mg/L for more than 4 hours during periods when the system is serving water to the public.

Reference: M20, Water Chlorination/Chlorination Practices and Principles, 2nd edition. 2006. American Water Works Association. Chapter 6.

71. Answer: c. HOCl.

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 8.

72. Answer: c. chlorine gas.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 13.

73. Answer: b. Superchlorinating reservoirs and storage tanks

Reference: M7, Problem Organisms in Water: Identification and Treatment, 3rd edition. 2003. American Water Works Association. Chapter 4.

74. Answer: c. 200mg/L

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 3.

75. Answer: a. at least 6 hours.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 3.

76. Answer: b. To stop the flow of water into the tank when it is full

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 3. 77. Answer: b. Use a corrosion chemical as treatment Reference: M7, Problem Organisms in Water: Identification and Treatment, 3rd edition. 2003. American Water Works Association. Chapter 11.

78. Answer: c. Vacuum

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 8.

79. Answer: c. iron pipe from the anode to the cathode.

Reference: Water Treatment, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Chapter 9.

80. Answer: d. Galvanic corrosion

Reference: Water Treatment, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Chapter 9.

81. Answer: d. Proper alignment and support for meter

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 10.

82. Answer: b. 2.5 feet.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

83. Answer: b. 18 inches.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

84. Answer: d. Just ahead of the pipe installation

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

85. Answer: a. 6%.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

86. Answer: c. Irregular drum tampers

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 13.

87. Answer: a. Hand-controlled plate tampers

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 13.

88. Answer: d. Mueller thread

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 15.

89. Answer: c. 12%

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12. 90. Answer: b. 12 to 24 inches; 3 inches

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

91. Answer: c. Local regulatory agency

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

92. Answer: b. 120 to $150\mathrm{ft}-\mathrm{lb}$

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

93. Answer: a. 4 inches or smaller.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 14.

94. Answer: b. Polyethylene pipe

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 15.

95. Answer: b. Flanged joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

96. Answer: b. Flanged joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

97. Answer: a. Ball and socket joint

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

98. Answer: c. 15.0 degrees.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2.

99. Answer: a. 3 degrees

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

100. Answer: a. 5 to 10%

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 10.

101. Answer: b. Plastic pipe

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

102. Answer: d. Boom-mounted plate tampers

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 13. 103. Answer: b. seal cage.

Reference: Pumping: Fundamentals for the Water and Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 3.

104. Answer: a. Directly

Reference: Pumping: Fundamentals for the Water and Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 3.

105. Answer: a. radial bearings.

Reference: Pumping: Fundamentals for the Water and Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 4.

106. Answer: c. slip.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 4.

107. Answer: a. Butterfly valves

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 4.

108. Answer: b. Globe valve

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 6.

109. Answer: a. Plug valve

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 6.

110. Answer: c. check valve.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 6.

111. Answer: c. Dry-barrel hydrant

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 7.

112. Answer: c. Thermocouples

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 9.

113. Answer: a. Thermistors

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 9.

114. Answer: b. pump head.

Reference: Pumping: Fundamentals for the Water and Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 2. 115. Answer: d. Valve opening and closing

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 5.

116. Answer: b. Altitude valve

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 6.

117. Answer: d. orifice plate.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 9.

118. Answer: b. 120%

Reference: Pumping: Fundamentals for the Water and Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 4.

119. Answer: b. 30.0 inches

Reference: Pumping: Fundamentals for the Water and Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Chapter 2.

120. Answer: d. 34 feet

Reference: Pumping: Fundamentals for the Water and Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 2.

121. Answer: d. to the pressure taps supplied on the pump.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 4.

122. Answer: d. Pressure-reducing and altitude valves

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 6.

123. Answer: d. Needle valve

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 6.

124. Answer: d. RTU's, communications, master station, and HMI

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 9.

125. Answer: d. DC currents.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 14.

126. Answer: a. zinc.

Reference: The Water Dictionary: A Comprehensive Reference of Water Terminology, 2nd edition. 2010. Nancy McTigue, Editor, and James M. Symons, Editor Emeritus. American Water Works Association.

127. Answer: a. Wound-rotor induction motor and a controller

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 8. 128. Answer: b. Voltage relays

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 8.

129. Answer: a. Thermal-overload relays

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 8.

130. Answer: c. Frequency relay

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 8.

131. Answer: d. Differential relay

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 8.

132. Answer: b. Sensor, transmitter, transmission channel, receiver, and indicator Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 9.

133. Answer: a. Demand meter

Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Electricity 3.

134. Answer: c. galvanic anodes.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 14.

135. Answer: a. Hot water

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 15.

136. Answer: c. racking.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 8.

137. Answer: a. 4 to 20 mA DC

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 9.

138. Answer: c. $Fe(OH)_2$ on the inside and $Fe(OH_3)$ on the outside

Reference: Basic Chemistry for Water and Wastewater Operators, Revised edition. 2005. Darshan Singh Sarai. American Water Works Association. Chapter 14.

139. Answer: d. Capacitor

Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Electricity 3.

140. Answer: d. equal to or slightly larger than

Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Electricity 3.
141. Answer: b. mechanical failure.
Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Electricity 3.

142. Answer: c. 6 months

Reference: Pumping: Fundamentals for the Water and Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 6.

143. Answer: b. Animal oil

Reference: Pumping: Fundamentals for the Water and Wastewater Maintenance Operator Series. 2001. Frank R. Spellman and Joanne Drinan. Technomic Publishing Company. Chapter 8.

144. Answer: b. At least 1.0 megohm of resistance

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 8.

145. Answer: b. 3 to 15 psig

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 9.

146. Answer: a. Extra thickness for pipe walls

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 14.

147. Answer: c. an analog (uses a needle) meter.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Glossary.

148. Answer: b. Paralyzes the respiratory system

Reference: Water Treatment, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Chapter 14.

149. Answer: b. 15 minutes

Reference: M20, Water Chlorination / Chlorination Practices and Principles, 2nd edition. 2006. American Water Works Association. Chapter 5.

150. Answer: c. 6.5 to 8.5pH units

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 1.

151. Answer: a. 6

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 13.

152. Answer: b. 13

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 13.

153. Answer: a. Sodium zinc phosphate

Reference: Water Treatment, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Chapter 9. 154. Answer: b. 8.

Reference: The Water Dictionary: A Comprehensive Reference of Water Terminology, 2nd edition. 2010. Nancy McTigue, Editor, and James M. Symons, Editor Emeritus. American Water Works Association.

155. Answer: c. Entry supervisor

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 13.

156. Answer: c. Authorized attendant

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 13.

157. Answer: d. by seeing the discoloration and moisture at the leak point.

Reference: Water Treatment, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Chapter 7.

158. Answer: a. 0.015mg/L

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 1.

159. Answer: c. cause health effects only after long exposure.

Reference: Water Treatment Operator Handbook, Revised edition. 2005. Nicholas G. Pizzi. American Water Works Association. Chapter 1.

160. Answer: b. galvanized pipe.

Reference: Water Treatment, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Chapter 9.

161. Answer: c. 5mg/L

Reference: Water Quality, 4th edition. 2010. Joseph A Ritter, Editor. American Water Works Association. Chapter 1.

162. Answer: d. The angle will vary with type of soil, moisture content, and surrounding conditions

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

163. Answer: d. 7.0MFL

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 1.

164. Answer: a. 80/60μg/L

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 1.

165. Answer: d. 5%

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 1.

166. Answer: c. Use activated carbon and flush the system

Reference: M7, Problem Organisms in Water: Identification and Treatment, 3rd edition. 2003. American Water Works Association. Chapter 11. 167. Answer: c. Pump head

Reference: Water Treatment, 4th edition. 2010. Nicholas G. Pizzi, Editor. American Water Works Association. Chapter 7.

168. Answer: a. Compound-loop control gas feeder

Reference: M20, Water Chlorination/Chlorination Practices and Principles, 2nd edition. 2006. American Water Works Association. Chapter 4.

169. Answer: b. chemical activity.

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 2.

170. Answer: d. gram-negative and strictly aerobic.

Reference: M7, Problem Organisms in Water: Identification and Treatment, 3rd edition. 2003. American Water Works Association, Chapter 4.

171. Answer: d. Ryzner index

Reference: Basic Chemistry for Water & Wastewater Operators, Revised edition. 2005. Darshan Singh Sarai. American Water Works Association. Chapter 14.

172. Answer: a. rad.

Reference: Water Quality, 4th edition. 2010. Joseph A. Ritter, Editor. American Water Works Association. Chapter 7.

173. Answer: b. bromate

Reference: National Primary Drinking Water Regulations, Subpart L Disinfectant Residuals, Disinfectant By-products and Disinfectant By-product Precursors, §141.132 - Monitoring requirements (b)(3)

174. Answer: a. 10mg/L; 2mg/L

Reference: M20, Water Chlorination / Chlorination Practices and Principles, 2nd edition. 2006. American Water Works Association. Appendix C.

175. Answer: a. 2 to 4 inches

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

176. Answer: b. 6 to 9 inches

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

177. Answer: a. globe valves.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 6.

178. Answer: c. 3 inches or greater.

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 12.

179. Answer: a. Shear breakage

Reference: Water Transmission and Distribution, 4th edition. 2010. Larry Mays, Editor. American Water Works Association. Chapter 2. 180. Answer: b. Globe valve

Reference: Water Distribution System Operation and Maintenance, 5 th edition. 2005. Ken Kerri. California State University - Sacramento. Page 120.

181. Answer: d. The hydraulic grade

Reference: Water Distribution System Operation and Maintenance, 5th edition. 2005. Ken Kerri. California State University - Sacramento. Page 63.

182. Answer: c. welded at the joints.

Reference: Water Distribution System Operation and Maintenance, 5th edition. 2005. Ken Kerri. California State University - Sacramento. Page 63.

183. Answer: c. 75 to less than 100 psi

Reference: Water Distribution System Operation and Maintenance, 5th edition. 2005. Ken Kerri. California State University - Sacramento. Page 69.

184. Answer: a. Pressure-reducing valves

Reference: Water Distribution System Operation and Maintenance, 5 th edition. 2005. Ken Kerri. California State University - Sacramento. Page 69.

185. Answer: b. 2 to 4ft/sec

Reference: Water Distribution System Operation and Maintenance, 5th edition. 2005. Ken Kerri. California State University - Sacramento. Page 71.

186. Answer: a. 6 inches

Reference: Water Distribution System Operation and Maintenance, 5th edition. 2005. Ken Kerri. California State University - Sacramento. Page 71.

187. Answer: c. 1,000 feet

Reference: Water Distribution System Operation and Maintenance, 5 th edition. 2005. Ken Kerri. California State University - Sacramento. Page 71.

188. Answer: b. fire demand.

Reference: Water Distribution System Operation and Maintenance, 5 th edition. 2005. Ken Kerri. California State University - Sacramento. Page 71.

189. Answer: d. Low pressure

Reference: Water Distribution System Operation and Maintenance, 5 th edition. 2005. Ken Kerri. California State University - Sacramento. Page 72.

190. Answer: a. Steel cylinder

Reference: Water Distribution System Operation and Maintenance, 5th edition. 2005. Ken Kerri. California State University - Sacramento. Page 78.

191. Answer: b. Lead

Reference: Water Distribution System Operation and Maintenance, 5 th edition. 2005. Ken Kerri. California State University - Sacramento. Page 81.

192. Answer: c. Dressler coupling

Reference: Water Distribution System Operation and Maintenance, 5 th edition. 2005. Ken Kerri. California State University - Sacramento. Page 81.
193. Answer: b. Victaulic joint
Reference: Water Distribution System Operation and Maintenance, 5 th edition. 2005. Ken Kerri. California State University - Sacramento. Page 81.

194. Answer: d. Restrained joint

Reference: Water Distribution System Operation and Maintenance, 5th edition. 2005. Ken Kerri. California State University - Sacramento. Page 81.

195. Answer: d. Cement mortar

Reference: Water Distribution System Operation and Maintenance, 5 th edition. 2005. Ken Kerri. California State University - Sacramento. Page 86.

196. Answer: a. 5 degrees

Reference: Water Distribution System Operation and Maintenance, 5th edition. 2005. Ken Kerri. California State University - Sacramento. Page 86.

197. Answer: a. Use of noncorrosive metals and/or mechanical coatings

Reference: Water Distribution System Operation and Maintenance, 5th edition. 2005. Ken Kerri. California State University - Sacramento. Page 88.

198. Answer: b. Calculating the operating and coverage ratios

Reference: Water Distribution System Operation and Maintenance, 5th edition. 2005. Ken Kerri. California State University - Sacramento. Page 469.

199. Answer: d. Through dedicated service-oriented employees

Reference: Water Distribution System Operation and Maintenance, 5 th edition. 2005. Ken Kerri. California State University - Sacramento. Page 466.

200. Answer: b. planning.

Reference: Water Distribution System Operation and Maintenance, 5 th edition. 2005. Ken Kerri. California State University - Sacramento. Page 444.

201. Answer: b. Containing not more than 0.02% lead

Reference: National Primary Drinking Water Regulations, Subpart E-Special Regulations, Including Monitoring Regulations And Prohibition On Lead Use, $141.43 - Prohibition on use of lead pipes, solder and flux (d)(1)

202. Answer: c. Containing not more than 8% lead

Reference: National Primary Drinking Water Regulations, Subpart E - Special Regulations, Including Monitoring Regulations And Prohibition On Lead Use, $141.43 - Prohibition on use of lead pipes, solder and flux (d)(2)

203. Answer: b. 1

Reference: National Primary Drinking Water Regulations, Subpart G-Maximum Contaminant Levels and Maximum Residual Disinfectant Levels, $141.63 Maximum contaminant levels (MCLs) for microbiological contaminants (a)(2)

204. Answer: a. 8 hours

Reference: National Primary Drinking Water Regulations, Subpart H - Filtration and Disinfection, §141.74 - Analytical and monitoring requirements (a)(1) Table explanation 2 205. Answer: a. warmest water temperature.

Reference: National Primary Drinking Water Regulations, Subpart U - Initial Distribution System Evaluations, 141.601 - Standard monitoring (b)(1) Table Endnote 2

206. Answer: d. 5 years

Reference: National Primary Drinking Water Regulations, Subpart U - Initial Distribution System Evaluations, 1141.601 - System specific studies (a)(1)(i)

207. Answer: b. 8 quarters

Reference: National Primary Drinking Water Regulations, Subpart U - Initial Distribution System Evaluations, $141.603 - 40/30 certification (a)

208. Answer: b. recommended in the Initial Distribution System Evaluation (IDSE) report.

Reference: National Primary Drinking Water Regulations, Subpart V - Stage 2 Disinfection By-products Requirements, $141.620 - General requirements (c)(6)(ii)

209. Answer: b. fourth quarter.

Reference: National Primary Drinking Water Regulations, Subpart V - Stage 2 Disinfection By-products Requirements, $141.620 - General requirements (c)(7)

210. Answer: a. disinfection by-products.

Reference: National Primary Drinking Water Regulations, Subpart V - Stage 2 Disinfection By-products Requirements, $141.621 - Routine monitoring (a)(2) Table Endnote 1

211. Answer: b. Within 10 days after the quarter ends

Reference: National Primary Drinking Water Regulations, Subpart V - Stage 2 Disinfection By-products Requirements, $141.629 - Reporting and recordkeeping requirements $(a)(1)(i$, ii)

212. Answer: c. First flush the volume of water between tap and lead service line, then collect the sample

Reference: National Primary Drinking Water Regulations, Subpart I - Control of Lead and Copper, $141.86 - Monitoring requirements for lead and copper in tap water (b)(3)(i, ii, iii)

213. Answer: c. When the 90th percentiles for lead and copper are 0.005mg/L and 0.65mg/L, respectively

Reference: National Primary Drinking Water Regulations, Subpart I - Control of Lead and Copper, $141.86 - Monitoring requirements for lead and copper in tap water (d)(4)(iv)

214. Answer: b. during June, July, August, and September.

Reference: National Primary Drinking Water Regulations, Subpart I - Control of Lead and Copper, $141.86 - Monitoring requirements for lead and copper in tap water $(d)(4)($ iv)

215. Answer: b. Once every 9 years

Reference: National Primary Drinking Water Regulations, Subpart I - Control of Lead and Copper, $141.86 - Monitoring requirements for lead and copper in tap water (g) 216. Answer: c. pH

Reference: National Primary Drinking Water Regulations, Subpart I - Control of Lead and Copper, $141.87 - Monitoring requirements for water quality parameters (c)(2)(i)

217. Answer: b. 3

Reference: National Primary Drinking Water Regulations, Subpart L Disinfectant Residuals, Disinfectant By-products and Disinfectant By-product Precursors, §141.132 - Monitoring requirements (c)(2)(ii)

218. Answer: c. the arithmetic average of all samples for TTHM and HAA5.

Reference: National Primary Drinking Water Regulations, Subpart L Disinfectant Residuals, Disinfectant By-products and Disinfectant By-product precursors, $141.134 - Reporting and recordkeeping requirements (b) Table - (1)(iii)

219. Answer: d. Preserve by keeping it at 4°C

Reference: National Primary Drinking Water Regulations, Subpart C - Monitoring and Analytical Requirements, $141.23 - Inorganic Chemical Sampling and Analytical Requirements (k)(2)

220. Answer: c. Preserve with H_2SO_4

Reference: National Primary Drinking Water Regulations, Subpart C - Monitoring and Analytical Requirements, $141.23 - Inorganic Chemical Sampling and Analytical Requirements (**k**)(2)

221. Answer: d. 1,000 mL

Reference: National Primary Drinking Water Regulations, Subpart I - Control of Lead and Copper, $141.86 - Monitoring requirements for lead and copper in tap water (b)(2)

222. Answer: d. Sequestering

Reference: Basic Science Concepts and Applications, 4th edition. 2010. Nicholas G. Pizzi, Editor. Chemistry 6.

223. Answer: b. resolubilize the metals.

Reference: National Primary Drinking Water Regulations, Subpart I - Control of Lead and Copper, 141.86 - Monitoring requirements for lead and copper in tap water (b)(2)

224. Answer: a. reduce the number of sites sampled.

Reference: National Primary Drinking Water Regulations, Subpart I - Control of Lead and Copper, $141.87 - Monitoring requirements for water quality parameters (e)(1)

225. Answer: b. Every 4 hours

Reference: National Primary Drinking Water Regulations, Subpart H - Filtration and Disinfection, §141.74 - Analytical and monitoring requirements (b)(5)

39 Answers to Math Questions for Water Distribution Operators Levels I & ||

1. Answer: b. 142gpm

Equation: Well yield, gpm $= \frac{\text{Gallons produced}}{\text{Test duration, min}}$
Well yield, gpm $= \frac{2{,}840\text{gpm}}{20 \text{ min}} = 142\text{gpm}$

2. Answer: a. 3.0°C

Equation: $°\text{C} = (°\text{F} - 32) \times 5/9$
First: $37.4 - 32 = 5.4$
Then: $5.4 \times 5 = 270 \div 9 = 3.0°\text{C}$

3. Answer: c. $8,170\text{ft}^2$

Equation: Area $= \pi \text{r}^2$, where $\pi = 3.14$
First find the radius: Radius = Diameter $/2 = 102/2 = 51$ft
Area of tank $= (3.14)(51\text{ft})(51\text{ft}) = 8,167.14\text{ft}^2$, round to $8,170\text{ft}^2$

4. Answer: a. 11.6psi

Equation: First subtract water level from the level in question, 1.85 feet.
Number of feet in question $= 28.7\text{ft} - 1.85\text{ft} = 26.85\text{ft}$
Pressure, psi $= (26.85\text{ft})(0.433\text{psi/ft}) = 11.626\text{psi}$, round to 11.6psi

5. Answer: d. 440gpm

Equation: Well yield, gpm = (Specific yield, gpm/ft)(Drawdown, ft)
Substitution: Well yield, gpm $= (31\text{gpm/ft})(14.1\text{ft}) = 437.1\text{gpm}$, round to 440gpm

6. Answer: c. 15,400 gal

First convert the diameter from inches to feet.
Number of feet $= \frac{18.0\text{in.}}{12\text{in./ft}} = 1.50\text{ft}$
Next, calculate the volume.
Equation: Pipe volume, gal $= (0.785)(\text{ Diameter, ft})^2(\text{ Length, ft})\left(7.48\text{gal/ft}^3\right)$
Pipe volume, gal $= (0.785)(1.50\text{ft})(1.50\text{ft})(1,165\text{ft})\left(7.48\text{gal/ft}^3\right)$
$= 15,391\text{gal}$, round to $15,400\text{gal}$

7. Answer: d. 45.5hr

First, convert gpm to gal per hour (gph): $(2,105\text{gpm})(60\text{ min/hr}) = 126,300\text{gph}$
Next, convert million gallons (mil gal) to gallons.
Water tank, gal $= (5.75\text{mil gal })(1,000,000) = 5,750,000\text{gal}$
Equation: Time, hr $=$ Number of gallons $\div$gph
Time, hr $= 5,750,000\text{gal} \div 126,300\text{gph} = 45.527\text{hr}$, round to 45.5hr 8. Answer: d. 8.3hr
First, convert pipe diameter from inches to feet.
Pipe diameter, ft $= (14\text{in}).(1\text{ft}/12\text{in}) = .1.167\text{ft}$
Next, find the number of gallons in the pipeline.
Number of gal $= (0.785)(\text{ Diameter, ft})^2(\text{ Length, ft})\left(7.48\text{gal/ft}^3\right)$
Number of gal $= (0.785)(1.167\text{ft})(1.167\text{ft})(549\text{ft})\left(7.48\text{gal/ft}^3\right) = 4,390\text{gal}$
Add the pipe and tank volume to get the total number of gallons.
Pipe and tank volume, gal $= 4,390\text{gal} + 2,310,000\text{gal} = 2,314,390\text{gal}$
Then convert mgd to gallons per day.
Number of gal $= (6.72\text{mgd})(1,000,000) = 6,720,000\text{gal/ day}$
Using the following equation, solve for the detention time.
Equation: Detention time, hr $= \frac{(\text{ Total Volume })(24\text{hr/ day })}{\text{Flow, gal/day}}$
Substitute known values and solve:
$\frac{(2{,}314{,}390\text{gal})(24\text{hr/ day })}{6{,}720{,}000\text{gal/ day}} = 8.266\text{hr}$, round to 8.3hr

9. Answer: d. 12,900 gpm

Number of gpm $= (28.7\text{cfs})(60\text{sec/min})\left(7.48\text{gal/ft}^3\right)$
$= 12,880.56\text{gpm}$, round to $12,900\text{gpm}$

10. Answer: a. 13.7 acre-ft

First, convert the number of liters to gallons.
Number of gal $= \frac{16{,}912{,}000\text{ liters}}{3.785\text{gal/ liter}} = 4,468,164\text{gal}$
Next convert gallons to acre-feet.
Number of acre-ft $= \frac{(\text{Number of gal })}{(43{,}560\text{ft}^3/\text{ acre- ft})(7.48\text{gal/ft}^3)}$
Number of acre-ft $= \frac{(4{,}468{,}164\text{gal})}{(43{,}560\text{ft}^3/\text{acre}-\text{ft})(7.48\text{gal/ft}^3)} = 13.713\text{acre} - \text{ft}$, round to 13.7 acre-ft

11. Answer: b. $-8.7°\text{F}$

Equation: $°F = (9/5 \times °C) + 32$

$$°F = (9/5 \times -22.6°C) + 32 = [(9 \times -22.6) \div 5] + 32 = (-203.4 \div 5) + 32$$
$$= -40.68 + 32 = -8.68°F, \text{ round to } -8.7°F$$

12. Answer: d. 113,000mg/L sodium hypochlorite

Know: 1% solution = 10,000mg/L
(11.3%)(10,000mg/L) = 113,000mg/L

13. Answer: c. 30,355gal/day

Equation: Pumped, gal/day = $\frac{\text{(Last read of gal pumped − First read of gallons pumped)}}{\text{Number of days}}$

$$\text{Pumped, gal/day} = \frac{(72,487,008\text{gal} - 71,576,344\text{gal})}{30 \text{ days}} = \frac{910,664\text{gal}}{30 \text{ days}}$$
$$= 30,355.467, \text{ round to } 30,355 \text{ gal/day}$$

14. Answer: b. 180lb/ day

Set up a ratio and solve for the unknown, x

$$\frac{x\text{lb/ day}}{16\text{cfs}} = \frac{260\text{lb/ day}}{23\text{cfs}}$$
$$x = \frac{(260\text{lb/ day })(16\text{cfs})}{23\text{cfs}} = 180\text{lb/ day}$$

15. Answer: c. 68.5ft

Equation: Circumference = (π)(Diameter)
Rearrange the equation to solve for the diameter.
Diameter = $\frac{\text{Circumference}}{\pi}$
Diameter = $\frac{215\text{ft}}{3.14} = \mathbf{68.5}\text{ft}$

16. Answer: d. 73.7ft deep

Equation: psi = $\frac{\text{Depth, ft}}{2.31\text{ft/psi}}$
Rearrange and solve:
Depth, ft = (31.9psi)(2.31ft/psi) = 73.689ft, round to 73.7ft

17. Answer: a. 4,970ft^2

Equation: Area = $(\pi)r^2$
Area = (3.14)(39.8ft)(39.8ft) = 4,973.8856ft^2, round to 4,970ft^2

18. Answer: b. 1.14 SG

Know: Water has a density of $62.4 \mathrm{lb}/\mathrm{ft}^3$.
Divide the density of the unknown by the density of water.
Equation: Specific Gravity (SG) = Density of substance ÷ Density of water
SG of the unknown liquid $= \frac{70.9 \mathrm{lb}/\mathrm{tt}^3}{62.4 \mathrm{lb}/\mathrm{ft}^3} = 1.14 \mathrm{SG}$

19. Answer: a. 15.7mgd

Equation: lb/day = (mgd)(Dosage, mg/L)(8.34lb/ day)
Rearrange to solve for mgd.
Treated amount, mgd = Chlorine, lb/ day ÷[(Dosage, mg/L)(8.34lb/gal)]
Treated amount, mgd = 295lb/ day ÷[(2.25mg/L)(8.34lb/gal)] = 15.7mgd

20. Answer: c. 1.3 gal sodium hypochlorite

First, find the volume of the pipe using.
Equation: Volume, gal $= (0.785)(\text{ Diameter, ft})^2(\text{ Length, ft})\left(7.48 \mathrm{gal}/\mathrm{ft}^3\right)$
Volume $= (0.785)(1.5)(1.5)(283 \mathrm{ft})\left(7.48 \mathrm{gal}/\mathrm{ft}^3\right) = 3,739 \mathrm{gal}$
Next, find the number of million gallons (mil gal).
milgal = (3,739gal)(1M/1,000,000) = 0.003739milgal
Then use the "pound" equation:
Sodium hypochlorite solution, lb $= \frac{(\text{milgal})(\text{Dosage,mg/L})(8.34 \mathrm{lb/gal})}{\%\text{ Available chlorine } \div 100\%}$
Sodium hypochlorite solution, lb $= \frac{(0.003739 \text{milgal})(50.0 \mathrm{mg/L})(8.34 \mathrm{lb/gal})}{12.1\%\text{ Available chlorine } \div 100\%}$

$$= 12.89 \mathrm{lb}$$

Lastly, calculate the number of gallons of sodium hypochlorite.
Sodium hypochlorite, gal = 12.89lb ÷ 9.92lb/gal = 1.299 gal, round to 1.3gal

21. Answer: a. 3.03mg/L

Equation: Chlorine, lb/day = (mgd)(Dosage, mg/L)(8.34lb/ day)
Rearrange to solve for dosage.

$$\textbf{Dosage, mg/L} = \frac{\textbf{Chlorine, lb/day}}{\textbf{(mgd)(8.34 lb/gal)}} = \frac{\textbf{415 lb/day}}{\textbf{(16.4 mgd)(8.34 lb/gal)}} = \textbf{3.03 mg/L}$$

22. Answer: c. 59 gal sodium hypochlorite

First, find the initial amount of water to be disinfected, 10% capacity

$$= (1.65 \text{milgal})(10\% \div 100\%) = 0.165 \text{milgal}$$

Next, determine the number of pounds of chlorine needed by using the "pounds" equation.
Sodium hypochlorite, lb $= \frac{(\text{mil gal })(\text{ Dosage, mg/L})(8.34 \mathrm{lb/gal})}{(\%\text{ Available chlorine})\ (100\%)}$
Sodium hypochlorite, 1 b $= \frac{(0.165 \text{milgal})(50.0 \mathrm{mg/L})(8.34 \mathrm{lb/gal})(100\%)}{(11.8\%)}$
Lastly, convert the pounds of sodium hypochlorite to gallons by dividing by 9.84 lb/gal.
Sodium hypochlorite, gal = 583.1lb ÷ 9.84lb/gal = 59.26, round to 59gal

23. Answer: c. 11.9lb calcium hypochlorite

First, convert 24 in. to feet: 24 in. $\div 12$ in. per foot $= 2$ft
Next, find the volume of the pipe in gallons using the following formula:
Equation: Pipe volume, gal $= (0.785)($ Diameter, ft$)^2($ Length, ft$)\left(7.48\text{gal}/\text{ft}^3\right)$
Pipe volume, gal $= (0.785)(2.0\text{ft})(2.0\text{ft})(781\text{ft})\left(7.48\text{gal}/\text{ft}^3\right) = 18,344\text{gal}$
Next, find the number of million gallons (mil gal).
mil gal $= (18,344\text{gal})(1\text{M} \div 1,000,000) = 0.018344\text{milgal}$
Then use the "pounds" equation:
Calcium hypochlorite, lb $= \frac{(\text{mil gal })(\text{ Dosage, mg/L})(8.34\text{lb/gal})}{(\%\text{ Available chlorine })(100\%)}$
Calcium hypochlorite, lb $= \frac{(0.018344\text{milgal})(50.0\text{mg/L})(8.34\text{lb/gal})}{(64.3\%)(100\%)} = \mathbf{11.91b}$ 24.
Answer: d. 26.0lb/ day of chlorine
First, convert the pumping rate to million gallons per day (mgd).
Equation: mgd $= \frac{(\text{ Pumping rate, } gpm)(1{,}440 \text{ min/ day })}{1{,}000{,}000}$
Substitute known values and solve: mgd $= \frac{(428\text{gpm})(1{,}440 \text{ min/day})}{1{,}000{,}000} = 0.61632\text{mgd}$
Next, find the total chlorine dose required.
Total chlorine dose, mg/L $= 1.20$mg/L required $+3.85$mg/L demand $=$ 5.05mg/L
Next, use the "pounds" equation to solve the problem.
Chlorine, lb/day $= (\text{mgd})(\text{ Dosage, mg/L})(8.34\text{lb/gal})$
$= (0.61632\text{mgd})(5.05\text{mg/L})(8.34\text{lb/gal})$
$= 25.958$lb/ day, round to 26.0lb/day

25. Answer: b. 74.4cfs

Equation: Number of cfs $= \frac{(\text{mgd})(1{,}000{,}000\text{gal})\left(1\text{ft}^3\right)(1\text{day})(1 \text{ min})}{(1\text{milgal})(7.48\text{gal})(1{,}440 \text{ min})(60\text{sec})}$
or: Number of cfs $= \frac{(\text{mgd})(1{,}000{,}000\text{gal})\left(1\text{ft}^3\right)(1\text{day})}{(1\text{milgal})(7.48\text{gal})(86{,}400\text{sec})}$
Substitute known values and solve.
Number of cfs $= \frac{(48.1\text{mgd})(1{,}000{,}000\text{gal})\left(1\text{ft}^3\right)(1\text{day})}{(1\text{milgal})(7.48\text{gal})(86{,}400\text{sec})} = \mathbf{74.4}$cfs

26. Answer: c. 11.6 L/s

Equation: Flow, L/s $= \frac{(Flow, gpm)(3.785 \text{ L/gal})}{60\text{sec/min}}$
Flow, L/s $= \frac{(184\text{gpm})(3.785 \text{ Liters /gal})}{60\text{sec/min}} = 11.6$ L/s

27. Answer: c. 1.02ntu

1	2	3	4	5	6	7
1.08ntu	0.98ntu	0.94ntu	0.88ntu	0.96ntu	1.03ntu	1.25ntu

First add all seven measurements:
$1.08 + 0.98 + 0.94 + 0.88 + 0.96 + 1.03 + 1.25 = 7.12$ntu
Equation: Average $= \frac{\text{Sum of measurements}}{\text{Number of measurements}}$
Average sedimentation basin ntu $= \frac{7.12\text{mg/L}}{7} = 1.017$ntu, round to 1.02ntu

28. Answer: a. 410

Equation: 100% Number $= \frac{\text{(Number given)(100\%)}}{\text{Percent of given number}}$

100% Number $= \frac{(288)(100\%)}{70.3\%} = 409.67$, round to 410 29. Answer: d. 99% Fe removal efficiency

Equation: Percent Fe removal efficiency $= \frac{(\text{ In } - \text{ Out })(100\%)}{\text{In}}$

Percent Fe removal efficiency $= \frac{(0.81-0.01)(100\%)}{0.81} = 99\%$ Fe removal efficiency

30. Answer: a. 3.27% soda ash slurry

Equation: Percent soda ash slurry $= \frac{\text{(Soda ash, lb)(100\%)}}{\text{Soda ash, lb}+(8.34\text{lb/gal})(\text{ Water, gal})}$

Substitute known values and solve.

$$\begin{aligned}
\text{Percent soda ash slurry } &= \frac{(28.2\text{lb})(100\%)}{28.2\text{lb} + (8.34\text{lb/gal})(100.0\text{gal})} \\
&= \frac{(28.2\text{lb})(100\%)}{28.2\text{lb} + 834\text{lb}} = \frac{(28.2\text{lb})(100\%)}{862.2\text{lb}} \\
&= \mathbf{3.27}\% \text{ soda ash slurry}
\end{aligned}$$

31. Answer: d. $11,100\text{ft}^2$

First, find the square footage of the wall area.

Equation: Wall area, $\text{ft}^2 =$ (Diameter, ft)(π)(Height, ft); where π equals 3.14

Wall area, $\text{ft}^2 = (80.1\text{ft})(3.14)(24.0\text{ft}) = 6,036\text{ft}^2$

Next, find the area of the top. Note: There is no bottom exterior area.

Top area, $\text{ft}^2 = (0.785)(\text{ Diameter, ft})^2 = (0.785)(80.1\text{ft})(80.1\text{ft}) = 5,037\text{ft}^2$

Total exterior surface area of tank, $\text{ft}^2 = 6,036\text{ft}^2 + 5,037\text{ft}^2$
$= 11,073\text{ft}^2$, round to $11,100\text{ft}^2$

32. Answer: c. 99,800gal

First, convert miles to feet:

Number of miles = (1.43miles)(5,280ft/mile) = 7,550.4ft

Next, convert 18.0 inches to feet:

Number of ft = 18.0 inches /12 inches per foot = 1.50ft

Substitute known values and solve.

Equation: Volume, gal $= (0.785)(\text{ Diameter, ft})^2(\text{ Length, ft}) \left(7.48\text{gal}^{\text{ft}}\text{ft}^3\right)$

Volume, gal $= (0.785)(1.50\text{ft})(1.50\text{ft})(7,550.4\text{ft}) \left(7.48\text{gal/ft}^3\right)$
$= 99,752$ gal, round to 99,800gal

33. Answer: b. 17.8hr

First, find the diameter: Diameter, ft = 2 (radius) = 2(60.0ft) = 120ft

Then, determine the volume of water in the storage tank.

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

Average Tank Volume, gal $= (0.785)(120\text{ft})(120\text{ft})(25.5\text{ft}) \left(7.48\text{gal}^2/\text{ft}^3\right)$

$= 2,156,125 \mathrm{gal}$

Next, convert mgd to gallons per day.

Flow through tank, gal/day = $(2.91 \mathrm{mgd})(1,000,000 \mathrm{gal}) = 2,910,000 \mathrm{gal/}$ day

Next, solve for the detention.

Equation: Detention time, hr = [(Tank Volume)(24hr/ day)] ÷ (Flow, gal/day) Substitute known values and solve:

Detention time, hr = $[(2,156,125 \mathrm{gal})(24 \mathrm{hr/\ day})] \div (2,910,000 \mathrm{gal/day}) = 17.8 \mathrm{hr}$

34. Answer: d. 58psi

Equation: Pressure Head, ft = (Pressure, psi)(2.31ft/psi)

Rearrange to solve for pressure in psi:

Pressure, psi = (Pressure head, ft) ÷ (2.31ft/psi)

Pressure, psi = $134 \mathrm{ft} \div 2.31 \mathrm{ft/psi} = 58 \mathrm{psi}$

35. Answer: a. 820gal

First, convert the flow in $\mathrm{ft}^3/\mathrm{min}$ to gallons per minute (gpm).

$\mathrm{gpm} = \left(5.5 \mathrm{ft}^3/\mathrm{min}\right)\left(7.48 \mathrm{gal/ft}^3\right) = 41.14 \mathrm{gpm}$

Then determine the number of gallons that flowed through the fire hydrant.

Gallons = (41.14gpm)(20 min) = 822.8gal, round to 820gal

36. Answer: b. 1.19 $\mathrm{g/cm}^3$

First, convert the number of pounds to grams.

Know from conversion tables that 1 pound = 454 grams and 1 liter = 1000.027 cm^3

Number of grams = (Number of lb)(454 g/lb)

Number of grams = $(8.25 \mathrm{lb})(454 \mathrm{~g/lb}) = 3,745.5 \mathrm{~g}$

Number of $\mathrm{cm}^3 = \left(1000.027 \mathrm{~cm}^3/1 \mathrm{~L}\right)(3.150 \mathrm{~L}) = 3,150.085 \mathrm{~cm}^3$

Equation: Density = Mass/Volume

Density $= 3,745.5 \mathrm{~g}/3,150.085 \mathrm{~cm}^3 = 1.19 \mathrm{~g/cm}^3$

37. Answer: b. 98.6% meter efficiency

First, convert cubic feet to gallons.

Number of gal $= \left(245.7 \mathrm{ft}^3\right)\left(7.48 \mathrm{gal/ft}^3\right) = 1,837.836 \mathrm{gal}$

Equation: Meter accuracy, % $= \frac{(\text{ Meter reading, gal })(100\%)}{\text{Actual volume, gal}}$

Meter accuracy, % $= \frac{(1,837.836 \mathrm{gal})(100\%)}{1,863 \mathrm{gal}} = 98.6\%$ meter efficiency

38. Answer: c. 3.3mg/L

Equation: lb/day = (mgd)(Dosage, mg/L)(8.34lb/ day)

Rearrange the equation and solve for dosage.

Dosage, mg/L = $\frac{\text{lb/ day}}{(\text{mgd})(8.34\text{lb/gal})} = \frac{320\text{lb/day}}{(11.6\text{mgd})(8.34\text{lb/gal})}$

= 3.308mg/L, round to 3.3mg/**L**

39. Answer: a. 678 gal of sodium hypochlorite

First, determine the number of pounds of chlorine needed by using the "pounds" equation.

Equation: Sodium hypochlorite, lb = (milgal)(Dosage, mg/L)(8.34lb/gal)

Chlorine, lb = (1.75milgal)(50.0mg/L)(8.34lb/gal) = 729.75lb

Next, find the number of gallons of sodium hypochlorite.

Equation: Sodium hypochlorite, gal = $\frac{(\text{Chlorine, lb})(100\%)}{(\text{lb/ gal})(\%\text{ Solution})}$

Substitute known values and solve.

Sodium hypochlorite, gal = $\frac{(729.75\text{lb of } Cl_2)(100\%)}{(8.97\text{lb/gal})(12.0\%)}$ = 677.95gal, round to 678gal

40. Answer: d. 54mg/L chlorine

First, convert the diameter of the pipeline from inches to feet.

Number of feet = 24.0 in. ÷12 in. /ft = 2.0ft

Next, find the number of gallons by determining the volume of the pipeline.

Equation: Volume of pipe, gal = (0.785) (Diameter, ft)^2(Length, ft)

Volume of pipe, gal = (0.785)(2.0ft)(2.0ft)(427ft) (7.48gal/ft^3) = 10,029gal

Then convert number of gallons to mil gal.

Number of mil gal = 10,029gal ÷ 1,000,000 = 0.010029milgal

Finally, calculate the dosage by rearranging the "pounds" equation.

Calcium hypochlorite, lb/day = $\frac{(\text{mgd})(\text{Dosage, mg/L})(8.34\text{lb/gal})(100\%)}{\text{Percent available chlorine}}$

Rearrange the equation and drop the day on each side of the equation as it is not needed.

Dosage, mg/L = $\frac{(\text{Calcium hypochlorite, lb})(65.0\%\text{ Available chlorine})}{(\text{mil gal})(8.34\text{lb/gal})(100\%\text{ calcium hypochlorite})}$

$$= \frac{(7.0)(65.0\%)}{(0.010029)(8.34)(100\%)}$$

$$= 54.4\text{mg/L, round to } 54\text{mg/L}$$

41. Answer: c. 7.4mg/L sodium hypochlorite

First, convert the production rate of the well pump to mgd.

Equation: mgd = $\frac{(\text{Pumping rate})(1{,}440\text{ min/ day})}{1{,}000{,}000}$

mgd = $\frac{(260\text{gpm})(1{,}440\text{ min/day})}{1{,}000{,}000\text{milgal}}$ = 0.3744mgd

Second, convert liters/day to gallons/day.

Number of gal = $\frac{95\text{ Liters / day}}{3.785\text{ Liters / gal}}$ = 25.1gal/ day

Next, calculate the chlorine usage in pounds per day. Equation:

Chlorine usage, lb/day

$$= \frac{(\text{ Hypochlorinator flow, gal/day })(\%\mathrm{Cl}_2 \text{ in hypochlorite solution })(8.95\mathrm{lb/gal})}{100\%}$$

$$= \frac{(25.1\mathrm{gal/day})(10.3\%)(8.95\mathrm{lb/gal})}{100\%} = 23.14\mathrm{lb/day}$$

Lastly, calculate the chlorine dosage using the "pounds" equation. Sodium hypochlorite, lb/day = [(mgd)(Dosage, mg/L)(8.34lb/gal)]

Rearrange the equation to solve for dosage.

Equation: Dosage, mg/L = $\frac{\text{Sodium hypochlorite, lb/ day}}{(\mathrm{mgd})(8.34\mathrm{lb/gal})}$

Dosage, mg/L = $\frac{23.14}{(0.3744)(8.34)} = 7.4\mathrm{mg/L}$ sodium hypochlorite

42. Answer: a. 10.5lb/ day of chlorine

First, convert the pumping rate to mgd.

Equation: $mgd = \frac{(\text{pumping rate, gpm })(1{,}440 \text{ min/ day })}{1{,}000{,}000}$

Substitute known values and solve:

mgd = $\frac{(208\mathrm{gpm})(1{,}440 \text{ min/ day })}{1{,}000{,}000} = 0.29952\mathrm{mgd}$

Next determine the total chlorine dosage required.

Total chlorine, mg/L = Chlorine demand, mg/L+ chlorine residual, mg/L

Total chlorine, mg/L = 2.45mg/L + 1.75mg/L = 4.20mg/L

Next, use the "pounds" equation to solve the problem.

Equation: Chlorine, lb/day = (mgd)(Dosage, mg/L)(8.34lb/gal)

Chlorine, lb/day = (0.29952mgd)(4.20mg/L)(8.34lb/gal) = **10.5**lb/ day chlorine

43. Answer: b. 910gpm

Know: 1hp = 33,000ft − lb/min

Convert 15hp to ft − lb/min : $15 \times 33{,}000 = 495{,}000$ft − lb/min

Solve for the unknown value, x :

(65)($x$lb/min) = 495,000ft − lb/min

$x$lb/min = 495,000ft − lb/min ÷ 65 = 7,615lb/min

Now express this maximum pumping rate in gallons per minute

7,615lb/min ÷ 8.34lb/gal = 913.70gpm, round to 910gpm

44. Answer: 128 gpcd

First, convert 2.98mgd to mil gal.

Number of gallons = 2.98mgd × 1,000,000milgal = 2,980,000gal

Equation:

Gallons per capita per day (gpcd) = Volume gal/day ÷ Population served/day

gpcd = 2,980,000gal/ day ÷23,210 capita/day = 128gpcd

40 Answers to Math Questions for Water Distribution Operators Levels Ill & IV

1. Answer: d. 1.4ft/sec

First, convert gpm to cubic feet per second (cfs).
Number of cfs $= \frac{122\text{gpm}}{(7.48\text{gal/ft}^2)(60\text{sec/min})} = 0.2718\text{cfs}$
Next, convert the diameter from inches to feet.
Number of ft $= (6.0 - \text{in})(1\text{ft}/12\text{-in}) = 0.50\text{ft}$
Equation: Flow, cfs $= (\text{ Area, } \text{ft}^2)(\text{ Velocity, ft/sec})$; where the Area $= (0.785)(\text{ Diameter })^2$
$0.2718\text{cfs} = (0.785)(0.50\text{ft})(0.50\text{ft})(\text{Flow, ft/sec})$
Rearrange and solve for the flow in ft/sec.
Flow, ft/sec $= \frac{0.2718\text{cfs}}{(0.785)(0.50\text{ft})(0.50\text{ft})} = 1.38$, round to 1.4ft/sec

2. Answer: b. 1,200lb

Equation: Pressure $= \frac{\text{Force, lb}}{\text{Area, ft}^2}$ for pressure on the small cylinder.
First convert 10 -inches to ft : $(10\text{in})(1\text{ft}/12\text{in}) = 0.833\text{ft}$
Pressure $= \frac{130\text{lb}}{(0.785)(0.833\text{ft})(0.833\text{ft})} = 238.66\text{lb/ft}^2$
Next, calculate the total force on the large cylinder.
Equation: Total force = (Pressure)(Area)
Total force $= (238.66\text{lb/ft}^2)(0.785)(2.5\text{ft})(2.5\text{ft}) = 1,170.926\text{lb}$, round to 1,200lb

3. Answer: c. 50mg/L

First, find the number of feet in 2.45 miles
Length in ft $= (5,280\text{ft/mile})(2.45\text{miles}) = 12,936\text{ft}$
Next, find the volume in cubic feet (ft^3) for the pipe.
Equation: Volume, $\text{ft}^3 = (0.785)(\text{ Diameter, ft})^2(\text{ Length, ft})$
Volume, $\text{ft}^3 = (0.785)(2.0\text{ft})(2.0\text{ft})(12,936\text{ft}) = 40,619.04\text{ft}^3$
Then, determine the number of gallons.
Number of gal $= (40,619.04\text{ft}^3)(7.48\text{gal/ft}^3) = 303,830.42\text{gal}$
Convert the number of gallons to million gallons (mil gal).
mil gal $= \frac{303,830.42\text{gal}}{1,000,000} = 0.30383\text{milgal}$
Lastly, find the dosage in mg/L.
Dosage, mg/L $= \frac{\text{lb of Chlorine}}{(\text{milgal})(8.34\text{lb/gal})} = \frac{126.9}{(0.30383)(8.34)}$
$= 50.08\text{mg/L}$, round to 50mg/L 4. Answer: d. 310mhp

$$\begin{aligned}
\text{Equation: Motor hp } &= \frac{\text{whp}}{(\text{ Motor effic. })(\text{ Pump effic. })} \\
\text{Motor hp } &= \frac{200 \text{ whp}}{(88\%/100\% \text{ Motor effic. })(74\%/100\% \text{ Pump effic. })} \\
&= \frac{(200\text{whp})}{(0.88 \text{ Motor effic. })(0.74 \text{ Pump effic. })} = 307\text{mhp, round to } 310 \textbf{ mhp}
\end{aligned}$$

5. Answer: c. 26 bhp

Solution: bhp $= \frac{(\text{ Bowl head, ft })(\text{ Capacity, gpm })}{(3960)(\text{ Bowl efficiency, }\%/100\%)}$

$$\text{bhp} = \frac{(215\text{ft})(385\text{gpm})}{(3960)(81\%/100\%)} = 25.8\text{bhp, round to } 2\mathbf{6hp}$$

6. Answer: c. 2.3ft/sec

Flow in 4.0-inch pipe equals the flow in the 3.0-inch pipe as the flow must remain constant: $Q_1 = Q_2$

Equation: (Area 1)(Velocity 1) = (Area 2) (Velocity 2)

First, find the diameter for the 3.0-inch and 4.0-inch pipes:

Diameter for 3.0-inch = (3.0-inch)(1ft/12-in) = 0.25ft

Diameter for 4.0-inch = (4.0-inch)(1ft/12-in) = 0.333ft

Then determine the areas of each size pipe: Area = $(0.785)(\text{ Diameter, ft})^2$

Area 1(3.0-in) = $(0.785)(0.25\text{ft})(0.25\text{ft}) = 0.049\text{ft}^2$

Area 2(4.0-in) = $(0.785)(0.333\text{ft})(0.333\text{ft}) = 0.087\text{ft}^2$

Lastly, substitute areas calculated and known velocity in 4.0-inch pipe.

$\left(0.049\text{ft}^2\right)(x, \text{ft/sec}) = \left(0.087\text{ft}^2\right)(1.3\text{ft/sec})$

Solve for x :

$$x, \text{ft/sec} = \frac{\left(0.087\text{ft}^2\right)(1.3\text{ft/sec})}{\left(0.049\text{ft}^2\right)} = 2.308\text{ft/sec, round to } 2.3\text{ft/sec}$$

7. Answer: b. 3,500gpm

First, find the water production during the 18-hour interval.

Gallons of water treated in 18-hr interval =

$$[(4.75\text{mgd})(1,000,000)(18\text{hrs})] \div 24\text{hrs} = 3,562,500\text{gal}$$

Next, find the gallons contained in the 2.3ft drop in water level.

$$\text{Volume, tank} = (0.785)(\text{ Diameter, ft})^2(\text{ Height })$$

$$\text{Volume of 2.3ft, 120ft diameter tank } = (0.785)(120\text{ft})(120\text{ft})(2.3\text{ft})\left(7.48\text{gal/ft}^3\right)$$
$$= 194,474\text{gal}$$

Production plus the loss in level is the amount the discharge pump had to send into the distribution system, but first find the number of minutes in 18hrs.

(18hrs)(60 min/hr) = 1,080 min

Then determine total gallons discharge pump moved.

Total gal discharge pump moved in 18hrs = 3,562,500gal + 194,474gal

$$= 3,756,974\text{gal}$$

Lastly, divide the number of gallons the discharge pump moved by the time in minutes.

Discharge pump, gpm $= 3,756,974\text{gal} \div 1,080$ min

$$= 3,479\text{gpm, round to } 3,500\text{gpm}$$

8. Answer: b. 0.4 gal of sodium hypochlorite

First, convert 1,000 gallons to million gallons:

Number of mil gal $= 1,000$ gal $\div 1,000,000 = 0.001$mil gal

Next determine the number of pounds of hypochlorite that are required using the "pounds" formula.

Equation: Sodium hypochlorite, lb $= \frac{(\text{ Dosage, mg/L})(\text{mil gal })(8.34\text{lb/gal})(100\%)}{\text{Percent sodium hypochlorite}}$

Substitute known values and solve:

Sodium hypochlorite, lb $= \frac{(50\text{mg/L})(0.001\text{mil gal })(8.34\text{lb/gal})(100\%)}{12.5\% \text{ Sodium hypochlorite}} = 3.736\text{lb}$

Lastly, determine the number of gallons of sodium hypochlorite by dividing by 9.34 lb/gal.

Sodium hypochlorite, gal $= 3.736\text{lb} \div 9.34\text{lb/gal} = \mathbf{0.4}\text{gal}$

9. Answer: b. 9.0% final solution

First, find the total volume that would result from mixing these two solutions:

Total Volume $= 350\text{gal} + 225\text{gal} = 575\text{gal}$

Then write the equation:

(Concentration $_1$) (Volume $_1$) + (Concentration $_2$) (Volume $_2$) = (Concentration $_3$) (Volume $_3$), or condensed as

$C_1 V_1 + C_2 V_2 = C_3 V_3$

where C_1 and C_2 = % Concentration of the two solutions before being mixed, V_1 and V_2 = Volume of the two solutions before being mixed, and C_3 and V_3 = the resulting % Concentration and Volume, respectively.

Substituting:

$$\frac{(11\%)(350\text{gal})}{100\%} + \frac{(5.8\%)(225\text{gal})}{100\%} = \frac{C_3(575\text{gal})}{100\%}$$
$$38.5\text{gal} + 13.05\text{gal} = \frac{C_3(575\text{gal})}{100\%}$$

Solving for C_3 :

$$C_3 = \frac{(38.5\text{gal} + 13.05\text{gal})(100\%)}{575\text{gal}} = \frac{(51.55\text{gal})(100\%)}{575\text{gal}} = 8.965, \text{ round to } 9.0\%$$

10. Answer: c. 32whp

Equation: $whp = \frac{(\text{ Pump rate, gpm })(\text{ Total head ,ft})(8.34\text{lb/gal})}{33{,}000\text{ft}-\text{lb/min/hp}}$

$$whp = \frac{(650\text{gpm})(195\text{ft})(8.34\text{lb/gal})}{33,000\text{ft} - \text{lb/min/hp}} = 32\text{whp}$$

11. Answer: a. 41.4%

Equation: Percent mixture

$$\frac{\frac{(\text{ Sol. 1-lb})(\text{Percent Strength of Sol. 1})}{100\%}+\frac{(\text{ Sol. 2-lb})(\text{Percent Strength of Sol. 2})}{100\%}(100\%)}{\text{Sol. 1-lb} + \text{Sol. 2-lb}}$$

Where Sol. = solution

Substitute known values and solve:

$$\text{Percent mixture} = \frac{\frac{(875\text{lb})(49.5\%)}{100\%}+\frac{(293\text{lb})(17.2\%)}{100\%}(100\%)}{875\text{lb}+293\text{lb}}$$

Reduce:

$$\text{Percent mixture} = \frac{(433.125\text{lb}+50.396\text{lb})(100\%)}{1{,}168\text{lb}} = \frac{(483.521\text{lb})(100\%)}{1{,}168\text{lb}}$$

$$= 41.397\%, \text{ round to } 41.4\%$$

12. Answer: d. 30oz

First, find the diameter in feet for both well casings.

Diameter for 12 -in. casing = 12 in. = 1.00ft

Diameter for 10 -in. casing = 10 in. ÷12 in. = 0.833ft

Then, find the length (in feet) of water in the casing.

Length of water-filled casing = Depth of well - Depth of water to top of casing

Length of water-filled casing for 12 -in. diameter = $100\text{ft} - 168.4\text{ft} = -68.4\text{ft}$; since it is negative there is no water in this section, and

Length of water-filled casing for 10 -in. diameter = $287\text{ft} - 168.4\text{ft} = 118.6\text{ft}$;

Next, determine the volume in gallons of water in the 10-in. casing using the equation:

Volume, in gal = $(0.785)(\text{ Diameter, } ft)^2(\text{ Length, ft})\left(7.48\text{gal}/\text{ft}^3\right)$

Vol., in gal for 10.0-inch casing = $(0.785)(0.833\text{ft})(0.833\text{ft})(118.6\text{ft})\left(7.48\text{gal}/\text{ft}^3\right)$

$$= 483\text{gal}$$

Next, determine the number of mil gal.

mil gal = $(483\text{gal})(1\text{M}/1,000,000) = 0.000483$mil gal.

Then, find the chlorine required.

Chlorine required = Chlorine demand + Chlorine residual.

Chlorine required = $4.7\text{mg/L} + 50.0\text{mg/L} = 54.7\text{mg/L}$

Then, using the "pounds" equation, calculate the number of lb of sodium hypochlorite.

Sodium Hypochlorite, lb = $\frac{(0.000483\text{milgal})(54.7\text{mg/L})(8.34\text{lb/gal})}{10.5\%/100\% \text{ available chlorine}}$

Sodium Hypochlorite, lb = 2.0985lb

Next, calculate the number of gallons of sodium hypochlorite required.

$2.0985\text{lb} \div 9.10\text{lb/gal} = 0.2306\text{gal}$

Lastly, convert to fluid ounces (oz):

Sodium hypochlorite, oz = $(0.2306\text{gal})(128\text{oz/gal}) = 29.5\text{oz}$, round to 30oz

13. Answer: c. $1,156.15

Equation: Cost, month $=$ (Hp)(hrs/ day)(# days)(0.746 kW/Hp)(Cost/kW$-$hr)

Substitute known values:

Cost, month $=$ (300Hp)(4.2hrs/ day)(30 days)(0.746 kW/Hp)($0.041/kW)

Cost, month $= \$1,156.15$

14. Answer: d. 14.81 mA

Equation:

Current process reading $= \frac{(\text{Live signal, mA}-4\text{ mA offset})(\text{Maximum capacity})}{16\text{ milliamp span}}$

Substitute known values and solve:

$16.55\mathrm{ft} = \frac{(\text{Live signal, mA}-4\text{ mA offset })(24.50\mathrm{ft})}{16\text{ mA span}}$

Rearrange formula to solve for the current number of milliamps.

Live signal, mA $-$ 4 mA offset $= \frac{(16.55\mathrm{ft})(16\text{ mA})}{24.50\mathrm{ft}}$

Live signal, mA $= \frac{(16.55\mathrm{ft})(16\text{ mA})}{24.5\mathrm{ft}} + 4$ mA

Live signal, mA $=$ 10.808 mA $+$ 4 mA $=$ 14.808 mA, round to 14.81 mA

15. Answer: b. 21,900 gal

First, convert the pipe diameters from inches to feet.

Large pipe, ft $=$ 14-in. $\div$12-in. $=$ 1.167ft

Small pipe, ft $=$ 10-in. $\div$12 in. $=$ 0.833ft

Next, convert the diameter in feet to the radius in feet by dividing by 2 .

Large pipe, ft $= 1.167\mathrm{ft} \div 2 = 0.5835\mathrm{ft}$

Small pipe, ft $= 0.833\mathrm{ft} \div 2 = 0.4165\mathrm{ft}$

Next determine the gallons in the 14-inch pipe and then the 10-inch pipe.

Equation: Number, gal $= 2/3(\text{ Length, ft})(\pi)(\mathrm{r})^2\left(7.48\mathrm{gal}/\mathrm{ft}^3\right)$; for large pipe

where r $=$ radius and $\pi = 3.14$

Number, gal $= 2/3(3,270\mathrm{ft})(3.14)(0.5835)^2\left(7.48\mathrm{gal}/\mathrm{ft}^3\right) = 17,432.89\mathrm{gal}$

Number, gal $= 1/3(\text{ Length, ft})(\pi)(\mathrm{r})^2\left(7.48\mathrm{gal}/\mathrm{ft}^3\right)$

Number, gal $= 1/3(3,270\mathrm{ft})(3.14)(0.4165)^2\left(7.48\mathrm{gal}/\mathrm{ft}^3\right) = 4,441.07\mathrm{gal}$

Lastly add the number of gallons for each pipe together.

Total number of gal $= 17,432.89+4,441.07 = 21,873.96$, round to $21,900\mathrm{gal}$

16. Answer: b. 290lb

Equation: % Lime $= \frac{(x\mathrm{lb})(100\%)}{x\mathrm{lb}+(\text{ Water, gal })(8.34\mathrm{lb}/\mathrm{gal})}$

$$15\%\text{ Lime } = \frac{(x\mathrm{lb})(100\%)}{x\mathrm{lb} + (200\mathrm{gal})(8.34\mathrm{lb}/\mathrm{gal})}$$

Multiply both sides of the equation by $\{x\mathrm{lb} + (200\mathrm{gal})(8.34\mathrm{lb}/\mathrm{gal})\}$. This leaves the following: 15% Lime $\{x\mathrm{lb} + (200\mathrm{gal})(8.34\mathrm{lb}/\mathrm{gal})\} = (x\mathrm{lb})(100\%)$

Complete the multiplication.

$15x\%, \mathrm{lb} + 25,020\%, \mathrm{lb} = 100x\%, \mathrm{lb}$

Subtract $15x\%, \mathrm{lb}$ from both sides of the equation.

$25,020\%, \mathrm{lb} = 85x\%, \mathrm{lb}$
Lastly, divide both sides of the equation by 85%.
$x = 294.35\mathrm{lb}$, round to **290 lb**

17. Answer: d. $1,540,000\mathrm{gal}$

Equation: Volume, gal $= \frac{(\mathrm{b}_1+\mathrm{b}_2)(\text{ Height, ft})(\text{ Length, ft})\left(7.48\mathrm{gal}/\mathrm{ft}^3\right)}{2}$
Volume, gal $= \frac{(5.85\mathrm{ft}+10.6\mathrm{ft})(4.10\mathrm{ft})(6{,}091\mathrm{ft})\left(7.48\mathrm{gal}/\mathrm{ft}^3\right)}{2}$
Volume, gal $= \frac{(16.45\mathrm{ft})(4.10\mathrm{ft})(6{,}091\mathrm{ft})\left(7.48\mathrm{gal}/\mathrm{ft}^3\right)}{2}$
Reduce problem by dividing 2 into 4.10ft
Volume, gal $= (16.45\mathrm{ft})(2.05\mathrm{ft})(6,091\mathrm{ft})\left(7.48\mathrm{gal}/\mathrm{ft}^3\right)$
Volume, gal $= 1,536,420\mathrm{gal}$, round to $1,540,000\mathrm{gal}$

18. Answer: b. 4.16hr

First, determine the number of gallons in the clearwell, distribution pipe, and storage tank.
Equation: Volume, gal $=$ (Length, ft)(Width, ft)(Depth, ft) $\left(7.48\mathrm{gal}/\mathrm{ft}^3\right)$
Clearwell volume, gal $= (308\mathrm{ft})(118\mathrm{ft})(12.85\mathrm{ft})\left(7.48\mathrm{gal}/\mathrm{ft}^3\right) = 3,493,313\mathrm{gal}$
Next, convert number of miles to feet.
Number of ft $= (5,280\mathrm{ft}/\mathrm{mi})(1.34\text{ miles }) = 7,075.2\mathrm{ft}$
Vol., gal in pipeline $= (0.785\mathrm{ft})(2.00\mathrm{ft})(2.00\mathrm{ft})(7,075.2\mathrm{ft})\left(7.48\mathrm{gal}/\mathrm{ft}^3\right)$
$= 166,177\mathrm{gal}$
Volume, gal $= (0.785)(\text{ Diameter, ft})^2(\text{ Height, ft})\left(7.48\mathrm{gal}/\mathrm{ft}^3\right)$
Vol., gal in tank $= (0.785)(99.8\mathrm{ft})(99.8\mathrm{ft})(26.48\mathrm{ft})\left(7.48\mathrm{gal}/\mathrm{ft}^3\right) = 1,548,639\mathrm{gal}$
Equation: Clearwell gal + Pipe gal + Tank gal = Total volume of gallons
$3,493,313\mathrm{gal} + 166,177\mathrm{gal} + 1,548,639\mathrm{gal} = 5,208,129\mathrm{gal}$
Next, convert average mgd to gallons per hour (gph).
$(30.02\text{ mgd } \div 24\text{ hours })(1,000,000) = 1,250,833\text{ gph}$
Now solve for detention time.
Equation: Detention time, hr $=$ Volume, gal $\div$ Flow rate, gph
Detention time, hr $= 5,208,129\mathrm{gal} \div 1,250,833\mathrm{gph} = 4.16\mathrm{hr}$

19. Answer: d. 51 psi

First, calculate the column of water in feet.
Water column $=$ Total depth of well $-$ Depth to water $-$ Number of ft above bottom Water column in ft $= 276.5 - 153.8\mathrm{ft} - 5.0\mathrm{ft} = 117.7\mathrm{ft}$
Next, find the pressure in psi.
Pressure, psi $=$ (Water column in ft)(0.433psi/ft)
Pressure, psi $= (117.7\mathrm{ft})(0.433\mathrm{psi}/\mathrm{ft}) = 50.96\mathrm{psi}$, round to 51psi

20. Answer: c. $1,250\mathrm{gpm}$

First, convert the diameter of the pipe from inches to feet.

Diameter, ft $= (10.0 \mathrm{in}).(1 \mathrm{ft}/12 \text{ in. }) = 0.833 \mathrm{ft}$

Next, calculate the pipe's cross-sectional area in square feet.

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

Area, $\mathrm{ft}^2 = (0.785)(0.833 \mathrm{ft})(0.833 \mathrm{ft}) = 0.5447 \mathrm{ft}^2$

Next, find the flow in the pipe in cfs.

Flow, cfs $= \left(\text{ Area, } \mathrm{ft}^2\right)(\text{ Velocity, ft/sec })$

Flow, cfs $= \left(0.5447 \mathrm{ft}^2\right)(5.10 \mathrm{ft/sec}) = 2.778 \mathrm{cfs}$

Last, determine the reading on the flowmeter in gpm.

Flow, gpm $= (2.778 \mathrm{cfs})\left(7.48 \mathrm{gal}/\mathrm{ft}^3\right)(60 \mathrm{sec}/\mathrm{min}) = 1,247 \mathrm{gpm}$, round to $1,250 \mathrm{gpm}$

21. Answer: a. 1.3ft/sec

Flow in 8.0-in. pipe equals the flow in the 10.0-in. pipe as the flow must remain constant: $Q_1 = Q_2$

Since Q_1 flow = (Area) (Velocity), it follows that:

(Area 1)(Velocity 1) = (Area 2)(Velocity 2)

First, find the diameters in feet for the 8.0-in. and 10.0-in. pipes.

Diameter for 8.0-in. = 8.0 in. ÷12 in. = 0.667ft

Diameter for 10.0-in. = 10.0 in. ÷12 in. = 0.833ft

Then determine the areas of each size pipe: Area $= (0.785)(\text{ Diameter, ft})^2$

Area 1(8.0-in.) $= (0.785)(0.667 \mathrm{ft})(0.667 \mathrm{ft}) = 0.349 \mathrm{ft}^2$

Area 2(10.0-in.) $= (0.785)(0.833 \mathrm{ft})(0.833 \mathrm{ft}) = 0.5447 \mathrm{ft}^2$

Lastly, substitute areas calculated and known velocity in 8.0-in. pipe.

$\left(0.349 \mathrm{ft}^2\right)(2.0 \mathrm{ft/sec}) = \left(0.5447 \mathrm{ft}^2\right)(x, \mathrm{ft/sec})$

Solve for x, ft/sec.

$x, \mathrm{ft/sec} = \frac{\left(0.349 \mathrm{ft}^2\right)(2.0 \mathrm{ft/sec})}{\left(0.5447 \mathrm{ft}^2\right)} = 1.28 \mathrm{fps}$, round to 1.3ft/sec

22. Answer: c. 0.87ft/sec

First, convert the diameter in inches to feet.

Diameter, ft = 18 in. ÷12 in. = 1.5ft

Next, determine the cross-sectional area of the pipe.

Equation: Area, $\mathrm{ft}^2 = (0.785)(\text{ Diameter, ft})^2$

Area, $\mathrm{ft}^2 = (0.785)(1.5 \mathrm{ft})(1.5 \mathrm{ft}) = 1.76625 \mathrm{ft}^2$

Next, determine the cfs flowing in the 18.0-in. pipe.

Number of cfs $= (988,000 \mathrm{gal}/24 \mathrm{hr})\left(1 \mathrm{ft}^3/7.48 \mathrm{gal}\right)(1 \mathrm{hr}/3,600 \mathrm{sec}) = 1.5288 \mathrm{cfs}$

Lastly, determine the flow in ft/sec.

Equation: Flow, cfs $= \left(\text{ Area, } \mathrm{ft}^2\right)(\text{ Velocity, ft/sec})$

Rearrange the formula to solve for velocity.

Average velocity, ft/sec $= \text{Flow, cfs} \div \text{ Area, } {}^2\mathrm{ft}^2$

Substitute known values and solve.

Average velocity, ft/sec $= 1.5288 \mathrm{cfs} \div 1.76625 \mathrm{ft}^2$

$$= 0.8656 \mathrm{ft/sec}, \text{ round to } 0.87 \mathrm{ft/sec}$$

23. Answer: d. 8.61mg/L

First, convert the level drop in the tank from inches to feet.
Level drop, ft $= 8.03$ in. $\div 12$ in. $= 0.6692\mathrm{ft}$
Next, determine the amount of hypochlorite used.
Equation: Volume, gal $= (0.785)(\text{ Tank diameter, ft})^2(\text{ Level drop, ft})\left(7.48\mathrm{gal}/\mathrm{ft}^3\right)$
Volume, gal $= (0.785)(6.0\mathrm{ft})(6.0\mathrm{ft})(0.6692\mathrm{ft})\left(7.48\mathrm{gal}/\mathrm{ft}^3\right) = 141.46\mathrm{gal}$
Next, find how many pounds of available chlorine this is.
Chlorine, lb $= [(141.46\mathrm{gal})(8.34\mathrm{lb}/\mathrm{gal})(64.5\%)] \div 100\% = 760.96\mathrm{lb}$ of chlorine
Lastly, calculate the dosage.
Equation: Chlorine, lb $= (\mathrm{milgal})(\text{Dosage, mg/L})(8.34\mathrm{lb}/\mathrm{gal})$
Solve for dosage:
Dosage, mg/L $=$ Chlorine, lb $\div [(\mathrm{milgal})(8.34\mathrm{lb}/\mathrm{gal})]$
Dosage, mg/L $= 760.96\mathrm{lb} \div [(10.6\mathrm{milgal})(8.34\mathrm{lb}/\mathrm{gal})] = \mathbf{8.61}\mathrm{mg}/\mathrm{L}$

24. Answer: a. 0.17gal

First, find the length (in feet) of water in the casing.
Length of water-filled casing $=$ Depth of well $-$ Depth of water to top of casing
Length of water-filled casing $= 227\mathrm{ft} - 143\mathrm{ft} = 84\mathrm{ft}$
Then, convert the diameter from inches to feet.
Diameter, ft $= 12$ in. $= 1.0\mathrm{ft}$
Next, determine the volume in gallons of water in the well casing using the following equation:
Volume, gal $= (0.785)(\text{ Diameter, ft})^2(\text{ Length, ft})\left(7.48\mathrm{gal}/\mathrm{ft}^3\right)$
Volume, gal $= (0.785)(1.0\mathrm{ft})(1.0\mathrm{ft})(84\mathrm{ft})\left(7.48\mathrm{gals}/\mathrm{ft}^3\right) = 493.23\mathrm{gal}$
Next, determine the number of mil gal.
$\mathrm{milgal} = 493.23\mathrm{gal} \div 1,000,000 = 0.000493\mathrm{milgal}$
Using the "pounds" formula, calculate the number of lb of sodium hypochlorite needed.
$\mathrm{NaOCl, lb} = (0.000493\mathrm{milgal})(50.0\mathrm{mg}/\mathrm{L})(8.34\mathrm{lb}/\mathrm{gal}) = 0.20558\mathrm{lbNaOCl}$
Lastly, calculate the gallons of sodium hypochlorite solution required.
$\mathrm{NaOCl, gal} = [(\text{ Chlorine, lb})(100\%)] \div [(\mathrm{NaOCl, lb/gal})(\text{ Hypochlorite, \% })]$
$\mathrm{NaOCl, gal} = [(0.20558\mathrm{lb})(100\%)] \div [(9.59\mathrm{lb}/\mathrm{gal})(12.5\%)]$
$= 0.1715$ gal, round to 0.17galNaOCl 25. Answer: c. 12.6lb
First, calculate the number of gallons in the pipeline.
Equation: Pipeline, gal $= (0.785)(\text{ Diameter, ft})^2(\text{ Length, ft})\left(7.48\mathrm{gal}/\mathrm{ft}^3\right)$
Pipeline, gal $= (0.785)(2.50\mathrm{ft})(2.50\mathrm{ft})(1,058\mathrm{ft})\left(7.48\mathrm{gal}/\mathrm{ft}^3\right) = 38,827\mathrm{gal}$
Convert gallons to mil gal.
Number of $\mathrm{milgal} = 38,827\mathrm{gal} \div 1,000,000 = 0.038827\mathrm{milgal}$
Next, determine the number of pounds of calcium hypochlorite $\{Ca(OCl)_2\}$ needed using the modified version (accounting for the percent available chlorine) of the "pounds" formula.
$Ca(OCl)_2, \mathrm{lb} = [(\text{mil gal })(\text{ Dosage, mg/L})(8.34\mathrm{lb}/\mathrm{gal})(100\%)] \div 64.5\%$

$Ca(OCl)_2, lb = [(0.038827 mil gal)(25.0 mg/L)(8.34 lb/gal)(100\%)] \div 64.5\% = 12.6 lb$

26. Answer: b. 350 gal

First, determine the capacity of the tank in gallons.

Equation: Volume, gal $= (0.785)(\text{ Diameter, ft})^2(\text{ Height, ft})\left(7.48 gal/ft^{3^2}\right)$

Volume, gal $= (0.785)(84.0 ft)(84.0 ft)(24.25 ft)\left(7.48 gal/ft^3\right) = 1,004,712 gal$

Next, convert number of gallons to million gallons.

$1,004,712$ gal $\div 1,000,000 = 1.0047$ mil gal

Using the "pounds" formula, determine the chlorine pounds needed.

Chlorine, lb = (Volume, mil gal)(Dosage, mg/L)(8.34lb/gal)

Chlorine, lb $= (1.0047 mil gal)(50.0 mg/L)(8.34 lb/gal) = 418.96 lb$

NaOCl solution, gal $= [(\text{ Chlorine, lb})(100\%)] \div [(\text{NaOCl, lb/gal})(\text{Hypochlorite, }\%)]$

$= [(418.96 lb)(100\%)] \div [(9.59 lb/gal)(12.5\%)]$

$= 349.5$ gal, round to 350gal

27. Answer: c. 14 tablets

First, determine the volume of the pipeline in million gallons (mil gal).

Number of mil gal $= \left[(0.785)(\text{ Diameter, ft})^2(\text{ Length, ft})\left(7.48 gal/ft^3\right)\right] \div 1,000,000$

Number of mil gal $= \left[(0.785)(2.50 ft)(2.50 ft)(513 ft)\left(7.48 gal/ft^3\right)\right] \div 1,000,000$

$$= 0.0188$$

Next, determine the number of pounds of calcium hypochlorite needed.

Equation: $Ca(OCl)_2$, lb = [(mil gal)(Dosage, mg/L)(8.34lb/gal)]÷% Purity

$$Ca(OCl)_2, lb = [(0.0188 mil gal)(25.0 mg/L)(8.34 lb/gal)] \div [64.0\% \div 100\%]$$
$$= 6.12 lb$$

Lastly, find the number of tablets needed.

Number of Tablets = 6.12lb ÷ 0.45lb/ tablet = 13.6 tablets, round to 14 tablets

28. Answer: a. 43oz of NaOCl

First, find the length (in feet) of water in the casing.

Length of water-filled casing = Depth of well − Depth of water to top of casing

Length of water-filled casing = 210ft − 91ft = 119ft

Then convert the diameter from inches to feet.

Diameter, ft = 14.0 in. ÷12 in. /ft = 1.1667ft Next, determine the volume in gallons of water in the well casing using the following formula:

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

Volume, gal $= (0.785)(1.1667\text{ft})(1.1667\text{ft})(119\text{ft})\left(7.48\text{gal}/\text{ft}^3\right) = 951.12\text{gal}$

Next, determine the number of mil gal.

mil gal $= 951.12\text{gal} \div 1,000,000 = 0.000951\text{mil gal}$

Lastly, using the "pounds" formula, calculate the number of lb of sodium hypochlorite.

Sodium hypochlorite, lb

$$\begin{aligned} &= \frac{[(0.000951\text{milgal})(50.0\text{mg/L})(8.34\text{lb/gal})]}{(12.5\%\text{ Available chlorine}/100\%)} \\ &= 3.173\text{lb} \end{aligned}$$

Next, find the number of ounces sodium hypochlorite (NaOCl).

Number of ounces $= [(3.173\text{lb})(128\text{oz/gal})] \div [9.50\text{lb/gal}] = 42.75\text{oz}$, round to 43oz

29. Answer: c. 10.69mg/L

First, determine the amount of water released from the storage tank in mgd.

Number of mgd $= [(3,075\text{gpm})(1,440\text{ min/ day })] \div 1,000,000 = 4.428\text{mgd}$

Next, find the number of pounds of soda ash used for the day.

Soda ash, lb $= (124.5\text{grams/min})(1,440\text{ min/ day })(1\text{lb}/454\text{grams}) = 394.89\text{lb}$

Lastly, calculate the dosage.

Equation: Number of lb $=$ (mil gal)(Dosage, mg/L)(8.34lb/gal)

Solve for dosage.

Dosage, mg/L $=$ Soda ash, lb $\div$ [(milgal)(8.34lb/gal)]

Dosage, mg/L $= 394.89\text{lb}$, Soda ash $\div[(4.428\text{milgal})(8.34\text{lb/gal})] = 10.69\text{mg/L}$

30. Answer: a. 1,150gpm

First, find the water production during the 12-hr interval.

Gal of water treated in 12-hr interval $= [(4.75\text{mgd})(1,000,000)(12\text{hr})] \div 24\text{hr}$

Gal of water treated in 12-hr interval $= 2,375,000$ gal

Next, find the gallons contained in the 7.08ft drop in water level.

Volume, tank $= (0.785)(\text{ Diameter, ft})^2(\text{ Height, ft})$

Volume of 7.08ft in 149.8ft diameter tank

$$= (0.785)(149.8\text{ft})(149.8\text{ft})(7.08\text{ft})\left(7.48\text{gal}/\text{ft}^3\right)$$

Volume of 7.08ft in 149.8ft diameter tank $= 932,885\text{gal}$

Production plus the loss in level is the amount the discharge pump sent into the distribution system, but first find the number of minutes in 12hr.

$(12.0\text{hr})(60\text{ min/hr}) = 720\text{ min}$

Then determine total gallons discharge pumps moved.

Total gal discharge pumps moved in 12hr $= 2,375,000\text{gal} + 932,885\text{gal}$

$$= 3,307,885\text{gal}$$

Lastly, divide the number of gallons the discharge pumps moved by the time in minutes and the number of pumps. Discharge pumps, gpm $= 3,307,885$ gal $\div[(720\,\text{min})(4 \text{ pumps })]$

$$= 1,149\text{gpm, round to } 1,150\text{gpm}$$

31. Answer: c. 420hp

First, determine the pumping head for this pump.
Pumping head = Elevation of water storage tank - Elevation of pump
Pumping head $= 478.16\text{ft} - 170.84\text{ft} = 307.32\text{ft}$
Next, calculate the friction loss in the pipeline.
Friction loss $= [(2,107\text{ft})(1.57\text{ft})] \div 1000\text{ft} = 3.31\text{ft}$
Now, calculate the total head.
Total dynamic head (TDH) = Suction lift + pumping head + friction loss

$$+ \text{ velocity head}$$

$\text{TDH} = 2.5\text{ft} + 307.32\text{ft} + 3.31 + 2.38\text{ft} = 315.51\text{ft}$
Lastly, determine the required horsepower of the pump.

$$\begin{aligned}\text{Hp} &= [(\text{gpm})(\text{TDH})] \div [(3960)(\text{ Pump efficiency })(\text{ Motor efficiency })] \\ &= [(4,000\text{gpm})(315.51\text{ft})] \div [(3960)(85\%/100\%)(89\%/100\%)] \\ &= 421.28,\ \text{round to } 420\text{hp}\end{aligned}$$

32. Answer: b. 17ft, therefore NPSHA $<$ NPSHR so cavitation should occur
First determine the atmospheric pressure in feet:

Know: 1.09ft/ in. Hg. Thus:
Atmospheric pressure = (29.8 in. Hg)(1.11ft/in.Hg) = 33.078ft
Next determine the NPSHA.
$\text{NPSHA} = \text{AP, ft} - \text{SSL, ft} - \text{Hf, ft} - \text{VP, ft}$
$\text{NPSHA} = 33.078\text{ft} - 15.1\text{ft} - 0.61\text{ft} - 0.50\text{ft}$
NPSHA = 16.868ft, round to 17ft
Therefore: NPSHA 17ft $<$ NPSHR 18.4ft, so cavitation should occur.

33. Answer: a. 95

First, determine the energy loss in feet.
Energy loss, ft = Upstream gauge read $-$ Downstream gauge read
Energy loss, ft $= 120\text{ft} - 105\text{ft} = 15\text{ft}$
Next, calculate the slope.
Equation: Slope = (Energy loss, ft) $\div$ (Distance, ft)

$$\text{Slope } = 15\text{ft} \div 2,274\text{ft} = 0.0065963\text{ft}$$

Lastly, find the C Factor.

Equation: C Factor = Flow, gpm $\div(193.75)$(Pipe diameter, ft)$^{2.63}$(Slope, ft)$^{0.54}$

C Factor $= 1,225\text{gpm} \div \left[(193.75)(1.0\text{ft})^{2.63}(0.0065963\text{ft})^{0.54}\right]$

C Factor $= 1,225\text{gpm} \div [(193.75)(1.0)(0.06644)] = 95.16$, round to 95 34.

Answer: d. 14.8 mA

Equation: Current process reading

$$= \frac{(\text{Live signal, mA} - 4 \text{ mA offset})(\text{Maximum capacity})}{16\text{milliamp span}}$$

Substitute known values and solve:

22.89ft (Storage tank level)

$$= \frac{(\text{ Live signal mA} - 4 \text{ mA offset })(34.0\text{ft Maximum level })}{16 \text{ mA}}$$

Rearrange the equation to solve for live signal in mA.

Live signal mA $- 4$ mA offset $= \frac{(22.89\text{ft})(16 \text{ mA})}{34.0\text{ft}}$

Live signal mA $= \frac{(22.89\text{ft})(16 \text{ mA})}{34.0\text{ft}} + 4$ mA offset

$$= 10.77 \text{ mA} + 4 \text{ mA offset } = 14.77 \text{ mA, round to } 14.8 \text{ mA}$$

41 Appendix A: Formulas for Water Treatment, Distribution, and Laboratory Exams

ABC standardized exams include the following formula and conversion information as a reference for the examinee. Formulas and conversions in the tables should be used to solve calculations on the exam.

Alkalinity, as $\text{mgCaCO}_\text{s}/\text{L} = \frac{(\text{ Titrant volume, mL})(\text{ Acid normality })(50{,}000)}{\text{Sample volume, mL}}$

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

Area of circle $= (0.785)\left(\text{ Diameter }^2\right)$ or $(\pi)\left(\text{ Radius }^2\right)$

Area of cone (lateral area) $= (\pi)(\text{ Radius })\left(\sqrt{\text{ Radius }^2 + \text{ Height }^2}\right)$

Area of cone (total surface area) $= (\pi)(\text{ Radius })\left(\text{ Radius } + \sqrt{\text{ Radius }^2 + \text{ Height }^2}\right)$

Area of cylinder (total outside surface area) = 2(Surface area of ends) $+[(\pi)(\text{ Diameter})(\text{Height or Depth})]$

Area of rectangle = (Length)(Width)

Area of a right triangle $= \frac{(\text{ Base })(\text{ Height })}{2}$

Average (arithmetic mean) $= \frac{\text{Sum of terms}}{\text{Number of all terms}}$

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

Chemical feed pump setting, % Stroke $= \frac{(\text{ Desired flow })(100\%)}{\text{Maximum flow}}$

Chemical feed pump setting, mL/min $= \frac{(\text{ Flow, mgd })(\text{ Dose, mg/L})(3.785 \text{ L/gal})(1{,}000{,}000\text{gal/MG})}{(\text{Liquid, mg/mL})(24\text{hr/day})(60 \text{ min/hr})}$

Circumference of circle $= (\pi)(\text{ Diameter })$ Composite sample single portion $= \frac{(\text{ Instantaneous flow })(\text{ Total sample volume })}{(\text{Number of portions})(\text{Average flow})}$

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

Electromotive force (EMF), volts = (Current, amps)(Resistance, ohms) or E = IR

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

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

Filter backwash rise rate, in. /min $= \frac{\left(\text{ Backwash rate,gpm/ft}^2\right)(12\text{in/ft})}{(7.48\text{gal/ft}^3)}$

Filter drop test velocity, ft/min $= \frac{\text{Water drop, ft}}{\text{Time of drop, minutes}}$

Filter flow rate or backwash rate, $gpm/\text{ft}^2 = \frac{\text{Flow, gpm}}{\text{Filter area, ft}^2}$

Filter yield, lbs /hr/ft^2 $= \frac{(\text{ Solids loading, lbs/day })(\text{ Recovery, \%/100\%})}{(\text{Filter operation, hr/day})(\text{Area, ft}^2)}$

Flow rate, $cfs = \left(\text{ Area, ft}^2\right)(\text{ Velocity, } ft/\text{sec})$ or $Q = AV$, where: $Q =$ flow rate, $A =$ area, V = velocity

Force, pounds = (Pressure, psi)$\left(\text{ Area, in }^2\right)$

Gallons/Capita/Day (gpcd) $= \frac{\text{Volume of water produced, gpd}}{\text{Population}}$

Hardness, as mg$CaCO_3$/L $= \frac{(\text{Titrant volume, mL})(1{,}000)}{\text{Sample volume, mL}}$

Only when the titration factor is 1.00 of EDTA

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

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

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

Hydraulic loading rate, gpd/ft^2 $= \frac{\text{Total flow applied, gpd}}{\text{Area, ft}^2}$

Hypochlorite strength, % $= \frac{(\text{ Chlorine required, lb})\ (100)}{(\text{ Hypochlorite solution needed, gal })(8.34\text{lb/gal})}$

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

Mass, lb = (Volume, mil gal)(Concentration, mg/L)(8.34lb/gal)

Mass flux, lb/day = (Flow, mgd)(Concentration, mg/L)(8.34lb/gal)

Milliequivalent = (mL)(Normality)

Molarity $= \frac{\text{Moles of solute}}{\text{Liters of solution}}$

Normality $= \frac{\text{Number of equivalent weights of solute}}{\text{Liters of solution}}$

Number of equivalent weights $= \frac{\text{Total weight}}{\text{Equivalent weight}}$

Number of moles $= \frac{\text{Total weight}}{\text{Molecular weight}}$

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

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

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

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

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

Specific Gravity $= \frac{\text{Specific weight of substance, lb/gal}}{\text{Specific weight of water, lb/gal}}$ Surface loading rate/Surface overflow rate, gpd/ft^2 $= \frac{\text{Flow, gpd}}{\text{Area, ft}^2}$

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

Two Normal Equation = $N_1 \times V_1 = N_2 \times V_2$, where N = normality, V = volume or flow

Velocity, ft/sec = $\frac{\text{Flow rate ft}^3\text{/sec}}{\text{Area, ft}^2}$ or $\frac{\text{Distance, ft}}{\text{Time, sec}}$

Volume of cone = $1/3(.785)(\text{ Diameter }^2)(\text{ Height})$

Volume of cylinder = $(.785)(\text{ Diameter }^2)(\text{ Height })$

Volume of rectangular tank = (Length)(Width)(Height)

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

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

Weir overflow rate, gpd $/ft$ = $\frac{\text{Flow, gpd}}{\text{Weir length, ft}}$

Wire-to-water efficiency, % = $\frac{\text{whp}}{\text{Power input, mph}} \times 100$

Wire-to-water efficiency, % = $\frac{(\text{ Flow, gpm })(\text{ Total dynamic head, ft})(0.746\text{kw/HP})(100)}{(3{,}960)(\text{ Electrical demand, kW})}$

42 Alkalinity Relationships

Alkalinity, mg/L as $CaCO_3$		
Result of Titration	Hydroxide Alkalinity as $CaCO_3$	Carbonate A
P = 0	0	
P = 1/2 T	0	
P < 1/2 T	0	
P > 1/2 T	2P − T	2
P = T	T	
∗ Key: P = phenolphthalein alkalinity; T = total alkalinity		

43 Conversion Factors & Abbreviations

1 acre	=	43,560 square feet (ft^2)
1 acre foot (acre-ft)	=	326,000 gallons (gal)
1 cubic foot (ft^3)	=	7.48 gal
1 ft^3	=	62.4 pounds (lb)
1 cubic foot per second (cfs or ft^3/sec)	=	0.646 mgd
1 foot (ft)	=	0.305 meters
1 ft of water	=	0.433 psi
1 gal	=	3.79 liters (L)
1 gal	=	8.34 lb
1 grain per gallon (gpg)	=	17.1 mg/L
1 horsepower (HP)	=	0.746 kilowatts (kW) or 746 watts
1 HP	=	33,000 ft lb/min
1 mgd	=	1.55 cfs or ft^3/sec
1 mile	=	5,280 ft
1 million gallons per day (mgd)	=	694 gallons per minute (gpm)
1 lb	=	0.454 kilograms
1 lb/in^2	=	2.31 ft of water
1 ton	=	2,000 lb
1%	=	10,000 mg/L
π or pi	=	3.14159
°Celsius	=	(°Fahrenheit − 32) × (5⁄9)
°Fahrenheit	=	(°Celsius) × (9⁄5) + 32

44 Additional Abbreviations

bhp	brake horsepower
DO	dissolved oxygen
EDTA	ethylenediaminetetraacetic acid
g	grams
gpcd	gallons per capita per day
gpd	gallons per day
in.	inch(es)
mg/L	milligrams per liter
mhp	motor horsepower
mil gal	million gallons
min	minute(s)
mL	milliliter
ppb	parts per billion
ppm	parts per million
psi	pounds per square inch
Q	low

SS	settleable solids
TTHM	total trihalomethanes
TOC	total organic carbon
TSS	total suspended solids
VS	volatile solids
whp	water horsepower

45 Appendix B: Sample CT Tables for Giardia Inactivation

CT Values for 1.5 Log Inactivation of *Giardia* Cysts by Free Chlorine

pH = 6.9

TEMP. °C	Chlorine Concentration in mg/L													
	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0
0.5	94.80	96.80	99.60	101.60	104.40	107.20	109.40	112.20	114.20	117.00	119.80	121.80	124.60	126.60
1.00	89.40	91.36	93.80	95.80	98.24	100.84	102.80	105.44	107.40	110.00	112.48	114.44	116.88	118.88
2.00	84.00	85.92	88.00	90.00	92.08	94.48	96.20	98.68	100.60	103.00	105.16	107.08	109.16	111.16
3.00	78.60	80.48	82.20	84.20	85.92	88.12	89.60	91.92	93.80	96.00	97.84	99.72	101.44	103.44
4.00	73.20	75.04	76.40	78.40	79.76	81.76	83.00	85.16	87.00	89.00	90.52	92.36	93.72	95.72
5.00	67.80	69.60	70.60	72.60	73.60	75.40	76.40	78.40	80.20	82.00	83.20	85.00	86.00	88.00
6.00	64.32	66.12	67.12	68.92	69.92	71.56	72.72	74.52	76.16	77.96	79.12	80.76	81.76	83.72
7.00	60.84	62.64	63.64	65.24	66.24	67.72	69.04	70.64	72.12	73.92	75.04	76.52	77.52	79.44
8.00	57.36	59.16	60.16	61.56	62.56	63.88	65.36	66.76	68.08	69.88	70.96	72.28	73.28	75.16
9.00	53.88	55.68	56.68	57.88	58.88	60.04	61.68	62.88	64.04	65.84	66.88	68.04	69.04	70.88
10.00	50.40	52.20	53.20	54.20	55.20	56.20	58.00	59.00	60.00	61.80	62.80	63.80	64.80	66.60
11.00	47.12	48.72	49.72	50.72	51.52	52.52	54.12	55.12	56.12	57.72	58.56	59.56	60.52	62.16
12.00	43.84	45.24	46.24	47.24	47.84	48.84	50.24	51.24	52.24	53.64	54.32	55.32	56.24	57.72
13.00	40.56	41.76	42.76	43.76	44.16	45.16	46.36	47.36	48.36	49.56	50.08	51.08	51.96	53.28
14.00	37.28	38.28	39.28	40.28	40.48	41.48	42.48	43.48	44.48	45.48	45.84	46.84	47.68	48.84
15.00	34.00	34.80	35.80	36.80	36.80	37.80	38.60	39.60	40.60	41.40	41.60	42.60	43.40	44.40
16.00	32.24	33.08	34.04	34.88	35.04	35.88	36.68	37.68	38.48	39.32	39.64	40.48	41.28	42.12
17.00	30.48	31.36	32.28	32.96	33.28	33.96	34.76	35.76	36.36	37.24	37.68	38.36	39.16	39.84
18.00	28.72	29.64	30.52	31.04	31.52	32.04	32.84	33.84	34.24	35.16	35.72	36.24	37.04	37.56
19.00	26.96	27.92	28.76	29.12	29.76	30.12	30.92	31.92	32.12	33.08	33.76	34.12	34.92	35.28
20.00	25.20	26.20	27.00	27.20	28.00	28.20	29.00	30.00	30.00	31.00	31.80	32.00	32.80	33.00
21.00	23.64	24.44	25.28	25.44	26.08	26.44	27.08	28.04	28.08	28.88	29.68	29.88	30.68	30.84
22.00	22.08	22.68	23.56	23.68	24.16	24.68	25.16	26.08	26.16	26.76	27.56	27.76	28.56	28.68
23.00	20.52	20.92	21.84	21.92	22.24	22.92	23.24	24.12	24.24	24.64	25.44	25.64	26.44	26.52
24.00	18.96	19.16	20.12	20.16	20.32	21.16	21.32	22.16	22.32	22.52	23.32	23.52	24.32	24.36
25.00	17.40	17.40	18.40	18.40	18.40	19.40	19.40	20.20	20.40	20.40	21.20	21.40	22.20	22.20

Modified from *Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*.

CT Values for 1.5 Log Inactivation of *Giardia* Cysts by Free Chlorine

pH = 7.6

TEMP. °C	Chlorine Concentration in mg/L													
	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0
0.5	123.00	124.60	128.00	132.00	135.40	138.60	142.60	145.80	149.00	154.60	155.40	158.40	161.60	164.60
1.00	115.64	117.52	120.68	124.32	127.48	130.48	134.08	137.08	140.08	144.96	146.20	149.00	152.00	154.80
2.00	108.28	110.44	113.36	116.64	119.56	122.36	125.56	128.36	131.16	135.32	137.00	139.60	142.40	145.00
3.00	100.92	103.36	106.04	108.96	111.64	114.24	117.04	119.64	122.24	125.68	127.80	130.20	132.80	135.20
4.00	93.56	96.28	98.72	101.28	103.72	106.12	108.52	110.92	113.32	116.04	118.60	120.80	123.20	125.40
5.00	86.20	89.20	91.40	93.60	95.80	98.00	100.00	102.20	104.40	106.40	109.40	111.40	113.60	115.60
6.00	82.04	84.68	86.84	88.84	91.00	93.00	95.00	97.20	99.16	101.16	103.96	105.80	107.96	109.80
7.00	77.88	80.16	82.28	84.08	86.20	88.00	90.00	92.20	93.92	95.92	98.52	100.20	102.32	104.00
8.00	73.72	75.64	77.72	79.32	81.40	83.00	85.00	87.20	88.68	90.68	93.08	94.60	96.68	98.20
9.00	69.56	71.12	73.16	74.56	76.60	78.00	80.00	82.20	83.44	85.44	87.64	89.00	91.04	92.40
10.00	65.40	66.60	68.60	69.80	71.80	73.00	75.00	77.20	78.20	80.20	82.20	83.40	85.40	86.60
11.00	61.04	62.20	64.04	65.20	67.04	68.20	70.00	72.00	73.00	74.80	76.80	77.96	79.76	80.92
12.00	56.68	57.80	59.48	60.60	62.28	63.40	65.00	66.80	67.80	69.40	71.40	72.52	74.12	75.24
13.00	52.32	53.40	54.92	56.00	57.52	58.60	60.00	61.60	62.60	64.00	66.00	67.08	68.48	69.56
14.00	47.96	49.00	50.36	51.40	52.76	53.80	55.00	56.40	57.40	58.60	60.60	61.64	62.84	63.88
15.00	43.60	44.60	45.80	46.80	48.00	49.00	50.00	51.20	52.20	53.20	55.20	56.20	57.20	58.20
16.00	41.32	42.36	43.52	44.52	45.68	46.52	47.52	48.68	49.68	50.68	52.32	53.32	54.32	55.32
17.00	39.04	40.12	41.24	42.24	43.36	44.04	45.04	46.16	47.16	48.16	49.44	50.44	51.44	52.44
18.00	36.76	37.88	38.96	39.96	41.04	41.56	42.56	43.64	44.64	45.64	46.56	47.56	48.56	49.56
19.00	34.48	35.64	36.68	37.68	38.72	39.08	40.08	41.12	42.12	43.12	43.68	44.68	45.68	46.68
20.00	32.20	33.40	34.40	35.40	36.40	36.60	37.60	38.60	39.60	40.60	40.80	41.80	42.80	43.80
21.00	30.12	31.28	32.12	33.08	33.92	34.28	35.08	36.08	36.92	37.88	38.08	39.08	39.88	40.88
22.00	28.04	29.16	29.84	30.76	31.44	31.96	32.56	33.56	34.24	35.16	35.36	36.36	36.96	37.96
23.00	25.96	27.04	27.56	28.44	28.96	29.64	30.04	31.04	31.56	32.44	32.64	33.64	34.04	35.04
24.00	23.88	24.92	25.28	26.12	26.48	27.32	27.52	28.52	28.88	29.72	29.92	30.92	31.12	32.12
25.00	21.80	22.80	23.00	23.80	24.00	25.00	25.00	26.00	26.20	27.00	27.20	28.20	28.20	29.20

Modified from *Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources.* Copyright 1990, American Water Works Association.

46 Additional Resources

The following items are all available from the AWWA Bookstore : www.awwa.org/bookstore; 1.800.926.7337; custsve@awwa.org

Principles and Practices of Water Supply Operations (WSO): Water Sources, 4th edition. 2010. 192 pp. Hardback. 978-1-58321-782-5. Catalog No. 1955

WSO: Water Treatment, 4th edition. 2010. 512 pp. Hardback. 978-1-58321-777-1. Catalog No. 1956

Water Treatment Student Workbook, 4th edition. 2010. 120 pp. Softbound. 978-1-58321-794-8. Catalog No. 1966

WSO: Water Transmission and Distribution, 4th edition. 2010. 546 pp. Hardback. 978-1-58321-781-8. Catalog No. 1957

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WSO: Water Quality, 4th edition. 2010. 213 pp. Hardback. 978-1-58321-798-6. Catalog No. 1958

Water Quality Student Workbook, 4th edition. 2010. 63 pp. Softbound. 978-1-58321-794-8. Catalog No. 1968

WSO: Basic Science Concepts and Applications, 4th edition. 2010. 626 pp. Hardback. 978-1-58321-778-8. Catalog No. 1959

Basic Science Concepts and Applications Student Workbook, 4th edition. 2010. 200pp. Softbound. 978-1-58321-799-3. Catalog No. 1954

Basic Chemistry for Water & Wastewater Operators. 2005. Darshan Singh Sarai. 96 pp. Softbound. 978-1-58321-148-9. Catalog No. 20494

Basic Microbiology for Drinking Water Personnel, 2nd edition. 2006. Dennis Hill. 109 pp. Softbound. 978-1-58321-434-3. Catalog No. 20463

Math for Distribution System Operators. 2007. John Giorgi. 250pp. Softbound. 978-1-58321-455-8. Catalog No. 20628

Math for Water Treatment Operators. 2007. John Giorgi. 250pp. Softbound. 978-1-58321-454-1. Catalog No. 20618

Water Distribution Operator Training Handbook, 3rd edition. 2005. 286 pp. Softbound. 978-1-58321-372-8. Catalog No. 20428

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- Basic Mathematics 7 CEUs EL7
- Fundamentais of Chemistry for Water Professionals .8 CEUs EL12
- Things That Tripped Me Up on the Operator Certification Exam .2 CEUs EL88

48 Quality

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- Disinfection By-Products: Recent Research Raises Concern .2 CEUs EL105
- Endocrine Disruptors; Pharmaceuticals, and Personal Care Products Actions and Communication .2 CEUs EL17
- Harmful Algal Blooms: Cyanobacteria .2 CEUs EL20
- Inorganic Treatment: Avoiding Inadvertent Noncompliance .2 CEUs EL102
- New Approaches for Assessing Microbial Threats .2 CEUs EL103
- Optimizing Water Distribution System Quality .2 CEUs EL101
- Perchlorate and Emerging Contaminants: Where Are We Now? 2 CEUs EL72
- Plant to Tap: the Importance of Disinfection .2 CEUs EL79
- Quagga/Zebra Mussel Control .2 CEUs EL70

49 Resources & Reuse

- GeoScience in Water Aquifers .2 CEUs EL78
- Water Shortages: Finding a Solution .2 CEUs EL73

50 Treatment

- Best of Membrane Conference .2 CEUs EL81
- Chemicals: Best Practices for Quality Assurance .2 CEUs EL76
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- Chlorine Gas: Balancing Public Health .2 CEUs EL21
- Coagulation, Flocculation, and Sedimentation Basic .3 CEUs EL8
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- Filter Optimization Tips You Can Use .2CEUs EL107
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- High Tech Operator Course 3: Data Management 1.2 CEUs EL86
- High Tech Operator Certificate Program 3.6 CEUs EL87

- Membranes: Emerging Issues & Technologies .2 CEUs EL23
- Plant to Tap: The Importance of Disinfection 2 CEUs EL79
- Residuals Management and Disposal .2 CEUs EL77

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