

**Registration form**

**Chlorination 101 CEU Training Course \$100.00  
48 HOUR RUSH ORDER PROCESSING FEE ADDITIONAL \$50.00**

Start and Finish Dates: \_\_\_\_\_ *You will have 90 days from this date in order to complete this course*

List number of hours worked on assignment must match State Requirement. \_\_\_\_\_

Name \_\_\_\_\_ Signature \_\_\_\_\_  
*I have read and understood the disclaimer notice on page 2. Digitally sign XXX*

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Operator ID# \_\_\_\_\_ Exp Date \_\_\_\_\_

**Please circle/check which certification you are applying the course CEU's.**

Water Treatment \_\_\_\_\_ Distribution \_\_\_\_\_ Collection \_\_\_\_\_

Wastewater Treatment \_\_\_\_\_ Other \_\_\_\_\_

**Technical Learning College PO Box 3060, Chino Valley, AZ 86323  
Toll Free (866) 557-1746 Fax (928) 272-0747 [info@tlch2o.com](mailto:info@tlch2o.com)**

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**Professional Engineers**; Most states will accept our courses for credit but we do not officially list the States or Agencies. Please check your State for approval.

## **State Approval Listing URL...**

<http://www.abctlc.com/downloads/PDF/CEU%20State%20Approvals.pdf>

*You can obtain a printed version of the course from TLC for an additional \$129.95 plus shipping charges.*

## **AFFIDAVIT OF EXAM COMPLETION**

I affirm that I personally completed the entire text of the course. I also affirm that I completed the exam without assistance from any outside source. I understand that it is my responsibility to file or maintain my certificate of completion as required by the state or by the designation organization.

## **Grading Information**

In order to maintain the integrity of our courses we do not distribute test scores, percentages or questions missed. Our exams are based upon pass/fail criteria with the benchmark for successful completion set at 70%. Once you pass the exam, your record will reflect a successful completion and a certificate will be issued to you.

**All downloads are tracked and monitored for security purposes.**

# Chlorination 101 CEU Course Answer Key

Name \_\_\_\_\_ Telephone # \_\_\_\_\_

**Method of Course acceptance confirmation. Please fill this section**

**It is your sole responsibly to ensure this course is accepted for credit in your State. No refunds. Did you check with your State agency to ensure this course is accepted for credit?**

Website \_\_\_ Telephone Call \_\_\_ Email \_\_\_ Spoke to \_\_\_\_\_

**Did you receive the approval number, if applicable? \_\_\_\_\_**

***Please circle, underline, bold or X only one correct answer***

Please Circle, Bold, Underline or X, one answer per question. A **felt tipped pen** works best.

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| 1. A B C D  | 19. A B     | 37. A B C D | 55. A B     |
| 2. A B C D  | 20. A B C D | 38. A B C D | 56. A B     |
| 3. A B C D  | 21. A B C D | 39. A B C D | 57. A B C D |
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| 10. A B C D | 28. A B C D | 46. A B C D | 64. A B C D |
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| 12. A B C D | 30. A B     | 48. A B     | 66. A B     |
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| 15. A B C D | 33. A B     | 51. A B C D | 69. A B C D |
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**Amount of Time for Course Completion – How many hours you spent on course?**

**Must match State Hour Requirement \_\_\_\_\_ (Hours)**

*I understand that I am 100 percent responsible to ensure that TLC receives the Assignment and Registration Key. I will not hold TLC liable for any errors or damages and will abide with rules on page 2. I understand that TLC has a zero tolerance towards not following their rules, cheating or hostility towards staff or instructors. I need to complete the entire assignment for credit. There is no credit for partial assignment completion. My exam was proctored.*

*I will contact TLC if I do not hear back from them within 2 days of assignment submission. I will forfeit my purchase costs and will not receive credit or a refund if I do not abide with TLC's rules.*

**Please Sign that you understand and will abide with TLC's Rules.**

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**Signature**

***Please write down any questions you were not able to find the answers or that have errors***



*Please e-mail or fax this survey along with your final exam*

**CHLORINATION 101 CEU TRAINING COURSE  
CUSTOMER SERVICE RESPONSE CARD**

NAME: \_\_\_\_\_

E-MAIL \_\_\_\_\_ PHONE \_\_\_\_\_

**PLEASE COMPLETE THIS FORM BY CIRCLING THE NUMBER OF THE APPROPRIATE ANSWER IN THE AREA BELOW.**

Please rate the difficulty of your course.

Very Easy    0    1    2    3    4    5    Very Difficult

Please rate the difficulty of the testing process.

Very Easy    0    1    2    3    4    5    Very Difficult

Please rate the subject matter on the exam to your actual field or work.

Very Similar    0    1    2    3    4    5    Very Different

How did you hear about this Course? \_\_\_\_\_

What would you do to improve the Course?

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Any other concerns or comments.

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**Please fax the answer key to TLC  
(928) 272-0747  
Always call to confirm that we received your paperwork.**

*This course contains general EPA's SDWA federal rule requirements. Please be aware that each state implements water / sampling procedures/safety/ environmental / building regulations that may be more stringent than EPA's regulations. Check with your state environmental/health agency for more information. These rules change frequently and are often difficult to interpret and follow. Be careful to not be in non-compliance and do not follow this course for proper compliance.*

***Please write down any questions you were not able to find the answers or that have errors.***



## Chlorination 101 CEU Course Assignment

The Chlorination 101 CEU Assignment is available in Word on the Internet for your Convenience, please visit [www.ABCTLIC.com](http://www.ABCTLIC.com) and download the assignment and e-mail it back to TLC.

You will have 90 days from the start of this course to complete in order to receive your Professional Development Hours (PDHs) or Continuing Education Unit (CEU). A score of 70 % is necessary to pass this course. If you should need any assistance, please email all concerns and the completed manual to [info@tlch2o.com](mailto:info@tlch2o.com).

We would prefer that you utilize the enclosed answer sheet in the front, but if you are unable to do so, type out your own answer key. Please include your name and address on your manual and make copy for yourself.

Multiple Choice, please select only one answer per question. There are no intentional trick questions.

***Please write down any questions you were not able to find the answers or that have errors.***

### Disinfection Rule Section

#### Chlorine DDBP

1. Chloramines are formed by reactions with?

- A. Acid and  $\text{Cl}_2$
- B. Ammonia and  $\text{Cl}_2$
- C. Folic Acid and  $\text{Cl}_2$
- D. None of the above

2. These term means that chlorine is present as  $\text{Cl}$ ,  $\text{HOCl}$ , and  $\text{OCl}^-$  is called \_\_\_\_\_, and that which is bound but still effective is \_\_\_\_\_.

- A. Free available chlorine and Total
- B. Free and Residual
- C. Free available chlorine and Combined Chlorine
- D. None of the above

#### Microbial Regulations

3. Which rule was established to maintain control of pathogens while systems lower disinfection byproduct levels to comply with the Stage 1 Disinfectants/Disinfection Byproducts Rule and to control *Cryptosporidium*?

- A. Long Term 1 Enhanced Surface Water Treatment Rule
- B. Interim Enhanced Surface Water Treatment Rule
- C. Surface Water Treatment Rule
- D. None of the above

4. Which rule specifies treatment criteria to assure that these performance requirements are met; they include turbidity limits, disinfectant residual, and disinfectant contact time conditions?

- A. Long Term 1 Enhanced Surface Water Treatment Rule
- B. Interim Enhanced Surface Water Treatment Rule
- C. Surface Water Treatment Rule
- D. None of the above

### **EPA's Drinking Water Regulations for Disinfectants**

5. All disinfectants form DBPs in one of two reactions: Chlorine and chlorine-based compounds (halogens) react with organics in water causing the \_\_\_\_\_ to substitute other atoms resulting in halogenated by-products.
- A. Chlorine atom      C. Carbon atom  
B. Hydrogen atom      D. None of the above
6. Oxidation reactions are where chlorine \_\_\_\_\_ compounds present in water.
- A. Reduces      C. Oxidizes  
B. Forms      D. None of the above
7. \_\_\_\_\_ are also formed when multiple disinfectants are used.
- A. Secondary by-products      C. Chlorine and chlorine-based compounds (halogens)  
B. Primary by-products      D. None of the above
8. Which of the following rules requires systems using public water supplies from either surface water or groundwater under the direct influence of surface water to disinfect?
- A. TTHM and HAA5 Rule      C. Surface Water Treatment Rule (SWTR)  
B. DBP MCLs Rule      D. None of the above
9. The maximum contaminant level for the SWTR disinfection set by EPA. At this time, an MCL is set for only \_\_\_\_\_, and proposed for additional disinfection byproducts.
- A. TTHM and HAA5 Rule      C. A community water system (CWS)  
B. Total Trihalomethanes      D. None of the above
10. Which of the following rules require EPA to develop rules to balance the risks between microbial pathogens and disinfection byproducts?
- A. Amendments to the SDWA in 1996      C. Stage 1 Disinfectant and Disinfection Byproduct Rule  
B. SDWA in 1996      D. None of the above

### **Public Health Concerns**

11. Which of the following rules along with the Disinfection Byproducts Rule applies to all community and nontransient non-community water systems that treat their water with a chemical disinfectant?
- A. Groundwater Rule (GWR)      C. Long Term 2 Enhanced Surface Water Treatment Rule  
B. The Stage 1 Disinfectants      D. None of the above
12. Which of the following rules and Disinfection Byproduct Rule updates and supersedes the 1979 regulations for total trihalomethanes?
- A. DBPs      C. The Stage 1 Disinfectant  
B. The LT2 requirements      D. None of the above

### **Stage 2 DBP Rule Federal Register Notices**

13. Which of the following rules is one part of the Microbial and Disinfection Byproducts Rules, which are a set of interrelated regulations that address risks from microbial pathogens and disinfectants/disinfection byproducts?
- A. Groundwater Rule (GWR)      C. Long Term 2 Enhanced Surface Water Treatment Rule (LT2)  
B. The Stage 2 DBP rule      D. None of the above

(S) Means the answer can be plural or singular in nature

**Are THMs and HAAs the only disinfection byproducts?**

14. The presence of \_\_\_\_\_ is representative of the occurrence of many other chlorination DBPs; thus, a reduction in the TTHM and HAA5 generally indicates a reduction of DBPs from chlorination.

- A. Chlorine and chloramine
- B. Classes of DBPs
- C. TTHM and HAA5
- D. None of the above

**Chlorine By-Products**

15. The most common chlorination by-products found in U.S. drinking water supplies are?

- A. Chlorate and Chlorite
- B. Trihalomethanes (THMs)
- C. Ammonia and THMS
- D. None of the above

**The Principal Trihalomethanes are:**

16. Chloroform, bromodichloromethane, chlorodibromomethane, and bromoform. Other less common chlorination by-products include the haloacetic acids and haloacetonitriles. The amount of THMs formed in drinking water can be influenced by a number of factors, including the season and the source of the water.

- A. True
- B. False

17. THM concentrations are generally higher in winter than in summer, because concentrations of natural organic matter are greater and more chlorine is required to disinfect at colder temperatures.

- A. True
- B. False

18. THM levels are also low when wells or large lakes are used as the drinking water source, because organic matter concentrations are generally low in these sources. The opposite — high organic matter concentrations and high THM levels — is true when rivers or other surface waters are used as the source of the drinking water.

- A. True
- B. False

**Health Effects**

19. The available studies on health effects do not provide conclusive proof of a relationship between exposure to THMs and cancer or reproductive effects, but indicate the need for further research to confirm their results and to assess the potential health effects of chlorination by-products other than THMs.

- A. True
- B. False

**Risks and Benefits of Chlorine**

20. Many cities utilize the use ozone to disinfect their source water and to reduce formation of this parameter?

- A. Chlorate and Chlorite
- B. Trihalomethanes (THMs)
- C. Chloramines
- D. None of the above

21. \_\_\_\_\_ is a highly effective disinfectant, it breaks down quickly, so that small amounts of \_\_\_\_\_ or other disinfectants must be added to the water to ensure continued disinfection as the water is piped to the consumer's tap.

- A. Ozone, Chlorine
- B. Chlorite, Chlorine
- C. Chlorine Dioxide, Chlorine
- D. None of the above

(S) Means the answer can be plural or singular in nature

22. Modifying water treatment facilities to use \_\_\_\_\_ can be expensive, and \_\_\_\_\_ treatment can create other undesirable by-products that may be harmful to health if they are not controlled (e.g., bromate).
- A. Ozone, Chlorine                      C. Ozone, Ozone  
 B. Chlorite, Chlorine                  D. None of the above
23. Which term is a weaker disinfectant than chlorine, especially against viruses and protozoa; however, they are very persistent and, as such, can be useful for preventing re-growth of microbial pathogens in drinking water distribution systems?
- A. UV                                      C. Chloramines  
 B. Chlorite                                D. None of the above
24. Chlorine dioxide can be an effective disinfectant, but it forms?
- A. Chlorate and Chlorite              C. Chloramines  
 B. THMS                                 D. None of the above

## Waterborne Pathogens Section

### Primary Waterborne Diseases Section

25. Humans are the reservoir for the Salmonella typhi pathogen, which causes diarrheal illness, and also known as?
- A. Campylobacter                      C. Typhoid fever  
 B. Shigella dysenteriae              D. None of the above
26. Legionnaire's disease, which causes a severe pneumonia, and the second, \_\_\_\_\_, which is a non-pneumonia illness; it's typically an influenza-like illness, and it's less severe.
- A. Pontiac fever                        C. Typhoid fever  
 B. Yellow fever                         D. None of the above
27. Legionella, prevention. Legionella in water systems. Hot water in tanks should be maintained between \_\_\_\_\_ degrees Centigrade.
- A. 81 to 100                              C. 71 and 77  
 B. 110 to 210                            D. None of the above
28. Giardia prevention strategies for this pathogen include \_\_\_\_\_; filtration, coagulation, and halogenation of drinking water.
- A. Internal protection                C. Containment protection  
 B. Source protection                 D. None of the above
29. Schistosomatidae, the basics. It is a parasite. It is acquired through dermal contact, cercarial dermatitis. It is commonly known as?
- A. Swimmer's itch                      C. Hemorrhagic colitis  
 B. Beaver fever                         D. None of the above
30. Schistosomatidae prevention strategies for this pathogen include Placing boric acid on berms or interrupting the life cycle of the parasite by treating birds with a lead.
- A. True                                    B. False

(S) Means the answer can be plural or singular in nature

31. *Shigella* species, in the United States two-thirds of the shigellosis in the U.S. is caused by *Shigella dysenteriae* and the remaining one-third is caused by *Shigella Campylobacter*.  
 A. True      B. False
32. *Campylobacter*, the basics. It's a bacterium. It causes diarrheal illness.  
 A. True      B. False
33. *Campylobacter* is primarily associated with poultry, animals, and humans.  
 A. True      B. False
34. *Vibrio cholerae*, the basics. It's a virus. It causes diarrheal illness, also known as cholera. It is typically associated with aquatic environments, shell stocks, and human. *Vibrio cholerae* has also been associated with ship ballast water.  
 A. True      B. False

**Dangerous Waterborne Microbes**

35. Which of the following is a parasite that enters lakes and rivers through sewage and animal waste. It causes gastrointestinal illness (e.g. diarrhea, vomiting, and cramps)?  
 A. Coliform Bacteria    C. Protozoa  
 B. Cryptosporidium    D. None of the above
36. Which of the following is a species of the rod-shaped bacterial genus *Shigella*?  
 A. Fecal coliform bacteria    C. *Shigella dysenteriae*  
 B. Cryptosporidium          D. None of the above
37. Which of the following can cause bacillary dysentery?  
 A. Fecal coliform bacteria    C. *Shigella*  
 B. Cryptosporidium          D. None of the above
38. Which of the following are bacteria whose presence indicates that the water may be contaminated with human or animal wastes? Microbes in these wastes can cause short-term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms.  
 A. Fecal Coliform and *E. coli*          C. *Shigella dysenteriae*  
 B. Cryptosporidium                        D. None of the above

**Bacteria Sampling**

39. Water samples for \_\_\_\_\_ must always be collected in a sterile container.  
 A. Amoebas                    C. Viruses  
 B. Bacteria tests            D. None of the above

**Methods**

40. The MMO-MUG test, a product marketed as \_\_\_\_\_, is the most common. The sample results will be reported by the laboratories as simply coliforms present or absent.  
 A. Colilert                    C. Total coliform analysis  
 B. Coliform                    D. None of the above

(S) Means the answer can be plural or singular in nature

### Microbial Regulations

41. One of the key regulations developed and implemented by the United States Environmental Protection Agency (USEPA) to counter pathogens in drinking water is the Surface Water Treatment Rule.

- A. True      B. False

### Basic Types of Water Samples

42. It is important to properly identify the type of sample you are collecting.

- A. True      B. False

### The three (3) types of samples are:

43. Samples collected following a coliform present routine sample. The number of repeat samples to be collected is based on the number of \_\_\_\_\_ samples you normally collect.

- A. Repeat      C. Routine  
B. Special      D. None of the above

44. A PWS has a second Level 1 Assessment within a rolling 12-month period.

- A. Trigger: Level 1 Assessment      C. All of the above  
B. Trigger: Level 2 Assessment      D. None of the above

45. A PWS on state-approved annual monitoring has a Level 1 Assessment trigger in 2 consecutive years.

- A. Trigger: Level 1 Assessment      C. All of the above  
B. Trigger: Level 2 Assessment      D. None of the above

46. A PWS collecting fewer than 40 samples per month has 2 or more TC+ routine/ repeat samples in the same month.

- A. Trigger: Level 1 Assessment      C. All of the above  
B. Trigger: Level 2 Assessment      D. None of the above

### Positive or Coliform Present Results

47. If you are notified of a positive coliform test result you need to contact either the Drinking Water Program or your local county health department within 72 hours, or by the next business day after the MCL compliance violation

- A. True      B. False

### Heterotrophic Plate Count HPC

48. Heterotrophic Plate Count (HPC) --- formerly known as the Bac-T plate, is a procedure for estimating the number of live heterotrophic bacteria and measuring changes during water treatment and distribution in water or in swimming pools.

- A. True      B. False

### Heterotrophic Plate Count (Spread Plate Method)

49. Which of the following provides a technique to quantify the bacteriological activity of a sample?

- A. Colonies      C. Heterotrophic Plate Count  
B. Agar      D. None of the above

**Total Coliforms**

50. For systems that collect fewer than \_\_\_\_\_ samples per month, no more than one sample per month may be positive. In other words, the second positive result (repeat or routine) in a month or quarter results in a MCL violation.

- A. 40
- B. 100
- C. 200
- D. None of the above

**The following are acute violations:**

51. Which determines a violation of nitrate?

- A. Presence
- B. MCL
- C. MCLG
- D. None of the above

**Revised Total Coliform Rule (RTCR) Summary**

52. The RTCR establishes criteria for systems to qualify for and stay on for special increased monitoring, which could reduce water system problems for better system operation.

- A. True
- B. False

53. The RTCR requires public water systems (PWSs) to meet a legal limit for E. coli, as demonstrated by required monitoring.

- A. True
- B. False

54. The RTCR suggests the frequency and timing of required microbial testing based on, public water type and source water type.

- A. True
- B. False

55. EPA published the Revised Total Coliform Rule (RTCR) in the Federal Register (FR) on February 13, 2013 (78 FR 10269). It is the revision to the 1989 Total Coliform Rule (TCR).

- A. True
- B. False

56. The RTCR requires public water systems that are vulnerable to microbial contamination to identify and fix problems.

- A. True
- B. False

57. The water provider shall collect \_\_\_\_\_ on a regular basis (monthly, quarterly, annually). Have samples tested for the presence of total coliforms by a state certified laboratory.

- A. Routine water samples
- B. Reduced monitoring
- C. Microbial contamination
- D. Repeat water samples

58. For PWSs on quarterly or annual routine sampling, collect additional routine samples (at least 3) in the month after a \_\_\_\_\_.

- A. CCR(s)
- B. PN
- C. Total coliform positive samples
- D. TC+ routine or repeat sample

59. PWSs incur violations if they do not comply with the requirements of the RTCR. The violation types are essentially the same as under the TCR with few changes. The biggest change is no acute or monthly MCL violation for \_\_\_\_\_ only.

- A. CCR(s)
- B. PN
- C. Total coliform positive samples
- D. TC+ routine or repeat sample

60. Community water systems (CWSs) must use specific language in their CCRs when they must conduct an assessment or if they incur\_\_\_\_\_.

- A. CCR(s)
- B. PN
- C. An E. coli MCL violation
- D. TC+ routine or repeat sample

61. The water provider shall analyze all \_\_\_\_\_ that are total coliform positive (TC+) for E. coli.

- A. Routine or repeat water samples
- B. Reduced monitoring
- C. Microbial contamination
- D. Repeat water samples

## Summary

### Detailed Disinfection Supplement Section

#### Factors in Chlorine Disinfection: Concentration and Contact Time

62. CXT values [ final free chlorine concentration (mg/L) multiplied by minimum contact time (minutes)], offer water operators guidance in computing an effective combination of chlorine concentration and chlorine contact time required to achieve disinfection of water at a given temperature.

- A. True
- B. False

#### Understanding Cryptosporidiosis

63. Cryptosporidium is an emerging parasitic protozoan pathogen because its transmission has increased dramatically over the past two decades.

- A. True
- B. False

#### Understanding Giardia lamblia

64. Which of the following was discovered about 20-40 years ago, is another emerging waterborne pathogen?

- A. Cryptosporidium
- B. Giardia lamblia
- C. Corona 5
- D. None of the above

## Water Chemistry Section

### pH Testing Section

65. Measurement of pH for aqueous solutions can be done with a glass electrode and a pH meter, or using indicators like strip test paper.

- A. True
- B. False

66. In chemistry, pH is a measure of the acidity or basicity of an aqueous solution. Solutions with a pH greater than 7 are said to be acidic and solutions with a pH less than 7 are basic or alkaline.

- A. True
- B. False

67. The pH scale is traceable to a set of standard solutions whose pH is established by US EPA.

- A. True
- B. False

68. Because the alkalinity of many surface waters is primarily a function of carbonate, bicarbonate, and hydroxide content, it is taken as an indication of the concentration of these constituents.

- A. True
- B. False



## Halogens- Halides

69. What is the negative ion often referred to as?

- A. A halide proton
- B. A halide ion
- C. Diatomic Compound
- D. None of the above

70. Which of the following terms contains ions known as halides?

- A. Salts
- B. Organic halides
- C. Hydrastatic acid
- D. None of the above

71. Halide ions combined with single hydrogen atoms form the hydrohalic acids (i.e., HF, HCl, HBr, HI), a series of particularly strong acids, one being?

- A. Salts
- B. Organic halides
- C. Hydrastatic acid
- D. None of the above

72. Many synthetic organic compounds such as plastic polymers, and a few natural ones, contain halogen atoms; these are known as halogenated compounds or?

- A. Salts
- B. Organic halides
- C. Hydrastatic acid
- D. None of the above

## Chlorine

73. The only halogen is needed in relatively large amounts (as chloride ions) by humans?

- A. Chlorine
- B. Iodine
- C. Fluoride
- D. None of the above

## Chlorine Section

### Chlorine Gas Appearance and Odor

74. Chlorine is a greenish-yellow gas it will condense to an amber liquid at about \_\_\_\_\_ F or at high pressures.

- A. 32 degrees
- B. -29.2 degrees
- C. 29 degrees
- D. None of the above

75. Lengthy exposures to chlorine gas may result in \_\_\_\_\_. Odor thresholds ranging from 0.08 to part per million (ppm) parts of air have been reported.

- A. Exposure to chlorine
- B. Odor thresholds
- C. Olfactory fatigue
- D. None of the above

### Reactivity

76. Cylinders of chlorine may burst when exposed to elevated temperatures. When there is Chlorine in solution, this forms?

- A. Hydrogen sulfide
- B. Oxomonosilane
- C. A corrosive material
- D. None of the above

77. What is formed when chlorine is in contact with combustible substances (such as gasoline and petroleum products, hydrocarbons, turpentine, alcohols, acetylene, hydrogen, ammonia, and sulfur), reducing agents, and finely divided metals?

- A. Fires and explosions
- B. Odor thresholds
- C. Moisture, steam, and water
- D. None of the above

78. Chlorine reacts with hydrogen sulfide and water to form which substance?

- A. Hydrogen sulfide            C. Chlorinates  
B. Hydrochloric acid         D. None of the above

79. Chlorine is also incompatible with?

- A. Plastic        C. Moisture, steam, and water  
B. Palladium    D. None of the above

### Flammability

80. When there is a fire that involves chlorine, the firefight should be fought downwind from the minimum distance possible.

- A. True        B. False

### What Happens to Chlorine When it Enters the Environment?

81. When chlorine is released to soil, chlorine will react with moisture forming free unstable oxygen radicals.

- A. True        B. False

82. When released to air, chlorine will react with water to form hypochlorous acid and hydrochloric acid, which are easily removed from the atmosphere by generation of free oxygen radicals.

- A. True        B. False

### Chlorine Exposure Limits

83. Chlorine's Physical and chemical properties: A yellowish green, nonflammable and liquefied gas with an unpleasant and irritating smell.

- A. True        B. False

84. The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for chlorine is 10 PPM (3 milligrams per cubic meter (mg/m<sup>3</sup>)) as a ceiling limit. A worker's exposure to chlorine shall at no time exceed this ceiling level.

- A. True        B. False

85. OSHA PEL is?

- A. 10 PPM    C. 1,000 PPM  
B. 1 PPM     D. None of the above

86. Chlorine can be readily compressed into a clear, amber-colored liquid, a \_\_\_\_\_, and a strong oxidizer.

- A. Combustible gas            C. Noncombustible gas  
B. Combustible liquid         D. None of the above

87. Solid chlorine is about \_\_\_\_\_ times heavier than water and gaseous chlorine is about 2.5 times heavier than air.

- A. 1.5        C. 2.5  
B. 0.5        D. None of the above

88. Cl<sub>2</sub> IDLH is?

- A. 10 PPM    C. 1,000 PPM  
B. 0.1 PPM   D. None of the above

89. Cl<sub>2</sub> fatal exposure limit is?  
A. 10 PPM C. 1,000 PPM  
B. 0.1 PPM D. None of the above

### Disinfectant Qualities

90. Chlorine is so important in poultry processing that the US Department of Agriculture requires an almost constant chlorine rinse for much of the cutting equipment. In fact, no proven economical alternative to chlorine disinfection exists for use in Meat and poultry processing facilities.  
A. True B. False

### Properties

91. Because it is highly reactive, chlorine is usually found in nature bound with other elements like sodium, potassium, and magnesium.  
A. True B. False

92. Inorganic disinfectants have great usage of removing a wide variety of disease-causing germs from drinking water and wastewater as well as from hospital and food production surfaces.  
A. True B. False

93. In researching and synthesizing organic compounds some compounds that have at least one atom of the element carbon in their molecular structure. All living organisms, including humans, are composed of primarily of \_\_\_\_\_.  
A. Organic compounds C. Inorganic compounds  
B. Abundant chemical elements D. None of the above

94. What is a largest reservoir of dissolved chlorine weathered from the continents and transported to the oceans by Earth's rivers?  
A. Brine C. Ancient seawater  
B. Seawater D. None of the above

95. Chemical elements have their own set of unique properties and chlorine is known as \_\_\_\_\_-- so reactive, in fact, that it is usually found combined with other elements in the form of compounds.  
A. Synthesizing organic compound C. One of the most abundant chemical elements  
B. A very reactive element D. None of the above

96. Various states of chlorine includes when chlorine is isolated as a free element, chlorine is a greenish yellow gas, which is \_\_\_\_\_. It turns to a liquid state at -34°C (-29°F), and it becomes a yellowish crystalline solid at -103°C (-153°F).  
A. 2.5 times heavier than water C. 2.5 times heavier than air  
B. 2.5 times lighter than air D. None of the above

### Chlorine Gas Introduction

97. When chlorine is added into the water stream, chlorine hydrolyzes into?  
A. HCL C. Hypochlorous acid (HOCl), and hydrochloric acid (HCl)  
B. Bromoform D. None of the above

98. When chlorine hydrolyzation occurs, it provides an active toxicant, \_\_\_\_\_, which is pH-dependent. In alkaline cooling systems, it readily dissociates to form the hypochlorite ion (OCl<sup>-</sup>).  
A. HCl C. The hypochlorate ion (OCl<sup>-</sup>)  
B. HOCl D. None of the above

99. In alkaline conditions, \_\_\_\_\_ becomes the predominant species and lacks the biocidal efficacy of the non-dissociated form.  
 A. HCl                      C. OCl-  
 B. HOCl                    D. None of the above
100. Considerably more \_\_\_\_\_ is present at a pH of 7.0 than at pH 8.5.  
 A. HCl                      C. OCl-  
 B. HOCl                    D. None of the above
101. Chlorine can be non-selective, making it very sensitive to contamination from either cooling water makeup or from in-plant process leaks. \_\_\_\_\_, organic acids and organic compounds, sulfides, iron and manganese all easily react with HOCl.  
 A. Ammonia                      C. Chlorine gas  
 B. Sodium hypochlorite    D. None of the above
102. What is the term that best describes the amount of chlorine needed to react with contamination species and it must be satisfied before active HOCl is available to provide a free chlorine residual?  
 A. Chlorine demand                      C. Total residual  
 B. Hypochlorite ion (OCl-)              D. None of the above
103. Which of the following removes alkalinity, pH depression and system corrosion could occur?  
 A. HCl                      C. pH of 7.0 than at pH 8.5  
 B. HOCl                    D. None of the above
104. The combination of high chlorine demand in process-contaminated systems and the dissociation process in alkaline systems creates the need for greater chlorine feed to obtain the same microbial efficacy. This results in a higher concentration of HCl in the cooling system.  
 A. True    B. False
105. The chloride ion (Cl<sup>-</sup>) cannot damage or penetrate the passive oxide layer, leading to localized damage of the metal surface as does Hypochlorous acid (HOCl), and hydrochloric acid (HCl).  
 A. True    B. False
106. High chlorine concentrations have also been shown to directly attack traditional organic-based corrosion inhibitors. When these inhibitors are “deactivated,” the metal surface would then be susceptible to corrosion. Process Safety Management (PSM) guidelines dictated by the U.S. Occupational Safety and Health Administration (OSHA), discharge problems related to Chlorinated organic compounds such as trihalomethane (THM), dezincification of admiralty brass and delignification of cooling tower wood are other significant concerns associated with the use of chlorine.  
 A. True    B. False

### Pathophysiology

107. As far as chlorine safety and respiratory protection, the intermediate \_\_\_\_\_ of chlorine accounts for its effect on the upper airway and the lower respiratory tract.  
 A. Effects of Hydrochloric acid    C. Water solubility  
 B. Vapor from Chlorine gas        D. None of the Above
108. Respiratory exposure to \_\_\_\_\_ may be prolonged because its moderate water solubility may not cause upper airway symptoms for several minutes.  
 A. Hydrochloric acid              C. Plasma exudation  
 B. Chlorine gas                    D. None of the Above

109. The odor threshold for chlorine gas is approximately?  
A. 0.3-0.5 parts per million (ppm)      C. 3-5 parts per million (ppm)  
B. 3 parts per million (ppm)              D. None of the Above

### Mechanism of Activity

110. The mechanisms of cellular injury are believed to result from the oxidation of functional groups in cell components, from reactions with tissue water to form \_\_\_\_\_, and from the generation of free oxygen radicals.

- A. Generation of free oxygen radicals      C. Hypochlorous and hydrochloric acid  
B. Chlorine acid                                  D. None of the above

111. Chlorine gas should be stored in vented rooms that have panic bar equipped doors.

- A. True    B. False

112. Chlorine gas feeds out of the cylinder through a gas regulator. The cylinders are on a scale that operators use to measure the amount used each day. The chains are used to prevent the tanks from falling over.

- A. True    B. False

### Solubility Effects

113. Which of the following is highly soluble in water?

- A. Hydrochloric acid      C. Hypochlorous base  
B. H<sub>2</sub>SO<sub>4</sub>                      D. None of the above

114. Because it is highly water soluble, Hypochlorous acid has an injury pattern similar to?

- A. Hydrochloric acid      C. Ferric acid  
B. H<sub>2</sub>SO<sub>4</sub>                      D. None of the above

115. Which of the following may account for the toxicity of elemental chlorine and hydrochloric acid to the human body?

- A. Hydrochloric acid      C. Hypochlorous acid  
B. H<sub>2</sub>SO<sub>4</sub>                      D. None of the above

### Early Response to Chlorine Gas

116. If you mix ammonia with chlorine gas, this compound reacts to form \_\_\_\_\_.

- A. Chloramine gas      C. Sulfuric gas  
B. Chlorine gas              D. None of the Above

117. The early response to the odor threshold for chlorine depends on the (1) concentration of chlorine gas, (2) duration of exposure, (3) water content of the tissues exposed, and (4) individual susceptibility.

- A. True    B. False

### Pathological Findings

118. Chlorine is a highly reactive gas.

- A. True    B. False

119. Chlorine gas is greenish yellow in color and very toxic. It is heavier than air and will therefore sink to the ground if released from its container. It is the toxic effect of Chlorine gas that makes it a good disinfectant, but it is toxic to more than just waterborne pathogens; it is also toxic to humans. It is a respiratory irritant and it can also irritate skin and mucus membranes.

- A. True    B. False

120. Chlorine gas is sold as a compressed liquid, which is amber in color. Chlorine, as a solid, is heavier (less dense) than water. If the chlorine liquid is released from its container it will quickly return back to its liquid state.

A. True B. False

121. Chlorine gas is the most expensive form of chlorine to use. The typical amount of chlorine gas required for water treatment is 1-16 mg/L of water. Different amounts of chlorine gas are used depending on the quality of water that needs to be treated. If the water quality is good, a higher concentration of chlorine gas will be required to disinfect the water if the contact time cannot be increased.

A. True B. False

### Chlorine's Effectiveness

122. The effectiveness of chlorination depends on the \_\_\_\_\_ of the water, the concentration of the chlorine solution added, the time that chlorine is in contact with the organism, and water quality.

A. Chlorine residual C. Breakpoint  
B. Chlorine demand D. None of the above

123. Chlorine may not be accessible for disinfection because \_\_\_\_\_ in the water (like iron, manganese, hydrogen sulfide, and ammonia).

A. pH increases C. Required contact time  
B. Part of it combines with other chemicals D. None of the above

124. The amount of chlorine required to attain disinfection and that reacts with the other chemicals is the?

A. Chlorine residual C. Free chlorine residual  
B. Chlorine demand D. None of the above

125. Which term is used when disinfection decreases, as the concentration of the chlorine increases?

A. Breakpoint C. Required contact time  
B. Chlorine level D. None of the above

126. Chlorination is more effective as?

A. Water temperature increases C. Water cools down  
B. Chlorine demand increases D. None of the above

127. Chlorination becomes more alkaline and is less effective as the?

A. Water's pH increases C. Required contact time is maximized  
B. Water quality increases D. None of the above

128. Chlorination is less effective in?

A. Clear water C. Day time  
B. Cloudy (turbid) water D. None of the above

129. By adding a little more chlorine to what is already sufficient, this action will generally result in \_\_\_\_\_ that can be measured easily.

A. pH increases C. Required contact time  
B. A free chlorine residual D. None of the above

### Potent Germicide

130. Chlorine disinfectants can lower the level of many disease-causing microorganisms in drinking water to almost immeasurable levels.

A. True B. False

131. Chlorine is added to drinking water to destroy pathogenic (disease-causing) organisms. It can be applied in several forms: sodium hypochlorite solution, elemental chlorine (chlorine gas) and dry calcium hypochlorite.

- A. True B. False

### **Taste and Odor Control**

132. Chlorine disinfectants reduce many disagreeable tastes and odors. Chlorine oxidizes many naturally occurring substances such as \_\_\_\_\_, sulfides and odors from decaying vegetation.

- A. Hydrogen sulfide C. Slime bacteria, molds and algae  
B. Foul-smelling algae secretions D. None of the above

### **Biological Growth Control**

133. Chlorine disinfectants eliminate \_\_\_\_\_ that commonly grow in water supply reservoirs, on the walls of water mains and in storage tanks.

- A. Hydrogen sulfide C. Slime bacteria, molds and algae  
B. Foul-smelling algae secretions D. None of the above

### **Chemical Control**

134. Chlorine disinfectants destroy \_\_\_\_\_ (which has a rotten egg odor) and remove ammonia and other nitrogenous compounds that have unpleasant tastes and hinder disinfection. They also help to remove iron and manganese from raw water.

- A. Hydrogen sulfide C. Slime bacteria, molds and algae  
B. Algae secretions D. None of the above

### **Water Treatment**

135. Generally speaking, water is treated to render it suitable for human use and consumption. While the primary goal is to produce a biologically (disinfected) and chemically safe product, other objectives also must be met, including: no objectionable taste or odor; \_\_\_\_\_ and chemical stability.

- A. Low levels of color and turbidity C. Chemical or biological contamination  
B. Sediments D. None of the above

### **Water Distribution**

136. In the event of a significant intrusion of pathogens resulting, for example, from a broken water main, the level of the average " \_\_\_\_\_ " will be insufficient to disinfect contaminated water. In such cases, it is the monitoring of the sudden drop in the chlorine residual that provides the critical indication to water system operators that there is a source of contamination in the system.

- A. Chlorine residual C. Breakpoint Chlorination  
B. Potential threats D. None of the above

### **The Challenge of Disinfection Byproducts**

137. Which of the following happens when chlorine and other disinfectants react with natural organic matter in water?

- A. Microbial contamination C. Chemical compounds formed unintentionally  
B. Treatment barrier D. None of the above

### **Chlorine and Water System Security**

138. With passage of the Public Health Security and Bioterrorism Response Act of 2002, Congress required community water systems to assess their vulnerability to a terrorist attack and other intentional acts. As part of these vulnerability assessments, systems assess?

- A. Microbial contamination C. The transportation, storage and use of treatment chemicals  
B. Cost-effective methods D. None of the above

139. Water systems using elemental chlorine, in particular, must determine whether existing protection systems are adequate. If not, they must consider additional measures to reduce the likelihood of an attack or to mitigate the?

- A. Potential consequences
- B. Potential threats
- C. Critical assets
- D. None of the above

### Chlorination Chemistry

140. pH and temperature affect the ratio of hypochlorous acid to hypochlorite ions. As the temperature is decreased, the \_\_\_\_\_ increases.

- A. CT actual
- B. Free chlorine residual
- C. Ratio of hypochlorous acid
- D. None of the above

141. The disassociation of chlorine gas

(OCI - ): HOCl  $\rightarrow$  H<sup>+</sup> + OCl<sup>-</sup> Also expressed HOCl  $\rightarrow$  H<sup>+</sup> + OCl<sup>-</sup>  
(hypochlorous acid) (hydrogen) (hypochlorite ion)

- A. True
- B. False

142. All three forms of chlorine produce sodium hypochlorite when added to water.

- A. True
- B. False

143. Hypochlorous acid is a strong acid but a weak disinfecting agent. The amount of hypochlorous acid depends on the pH and temperature of the water.

- A. True
- B. False

### Types of Residual

144. Which of the following is a much stronger disinfecting agent, therefore, most water regulating agencies will require that your daily chlorine residual readings be of free chlorine residual?

- A. Chlorine demand
- B. Free chlorine residual
- C. Combined chlorine residual
- D. None of the above

145. Which of the following terms is where the chlorine demand has been satisfied, and any additional chlorine will be considered free chlorine?

- A. Chlorine residual
- B. "CT" disinfection concept
- C. Break-point chlorination
- D. None of the above

146. Total chlorine residual = free + \_\_\_\_\_.

- A. Chlorine demand
- B. Free chlorine
- C. Combined chlorine residual
- D. None of the above

147. In water, there are always other substances (interfering agents) such as iron, manganese, turbidity, etc., which will combine chemically with the chlorine, this is called the?

- A. Chlorine demand
- B. Free chlorine
- C. Combined chlorine residual
- D. None of the above

148. According to the text, once chlorine molecules are combined with these interfering agents, they are not capable of disinfection. \_\_\_\_\_ is much more effective as a disinfecting agent.

- A. Chlorine demand
- B. Free chlorine
- C. Combined chlorine residual
- D. None of the above

### Residual Concentration/Contact Time (CT) Requirements

149. Since monitoring for very low levels of pathogens in treated water is analytically very difficult, utilizing the \_\_\_\_\_ is recommended to demonstrate satisfactory treatment.

- A. Chlorine residual
- B. "CT" disinfection concept
- C. Break-point chlorination
- D. None of the above



150. Which of the following term = Concentration (mg/L) x Time (minutes)

- A. CT
- B. #C
- C. TC
- D. None of the above

151. The effective reduction in pathogens can be calculated by reference to standard tables of required?

- A. CT's
- B. #C
- C. TC
- D. None of the above

### Calculation and Reporting of CT Data

152. You can also calculate and record actual log reductions. Reduction Ratio = CT actual divide by?

- A. Reduction Ratio
- B. CT required
- C. "CT" disinfection concept
- D. None of the above

153. This shall be calculated daily, using either the maximum hourly flow and the disinfectant residual at the same time, or by using the lowest CT value if it is calculated more frequently.

- A. Free chlorine
- B. Disinfection CT values
- C. "CT" disinfection concept
- D. None of the above

154. Reduction Ratio should be reported, along with the appropriate pH, temperature, and?

- A. Reduction Ratio
- B. CT actual
- C. Disinfectant residual
- D. None of the above

155. Which of the following terms must be greater than 1.0 to be acceptable?

- A. Reduction Ratio
- B. CT actual
- C. Disinfectant residual
- D. None of the above

### Chlorine Review

156. What term describes the minimum amount of Chlorine needed to react in a water purification system; used as a monitoring measurement by system operators.

- A. Chlorine demand
- B. Free chlorine residual
- C. Combined chlorine residual
- D. None of the above

157. Operator may add \_\_\_\_\_ to chlorinated public water supplies to provide inorganic chloramines.

- A. Bromine
- B. Organic amines
- C. Ammonia
- D. None of the above

158. What term describes the concentration of residual chlorine in water present as dissolved gas ( $\text{Cl}_2$ ), hypochlorous acid ( $\text{HOCl}$ ), and/or hypochlorite ion ( $\text{OCl}^-$ )?

- A. Chlorine demand
- B. Free chlorine
- C. Combined chlorine residual
- D. None of the above

159. What term describes the concentration of chlorine in the water after the chlorine demand has been satisfied, the concentration is normally expressed in terms of total chlorine residual, which includes both the free and combined or?

- A. Chlorine demand
- B. Free chlorine
- C. Chlorine residual
- D. None of the above

160. \_\_\_\_\_ is defined as the residual chlorine existing in water in chemical combination with ammonia or organic amines that can be found in natural or polluted waters.
- A. Chlorine Residual                      C. Combined Chlorine  
B. Chlorine Demand                      D. None of the above

### Calcium Hypochlorite Section

161. Which of the following substances comes in two forms: powder and tablets?
- A. Calcium hypochlorite                      C. Sodium hypochlorite  
B. Hypochlorous Acid (HOCl)                      D. None of the above

### Description

162. Solid chlorine stands alone as the safest form of chlorine disinfection.
- A. True                      B. False

163. Solid chlorine requires only minimal safety equipment for handling; users can breathe easy knowing our tablets are safe for both people and the environment.
- A. True                      B. False

### Chlorine-Based Disinfectants Chloramines

#### Chloramine Disadvantages

164. Which residual in tap water can pass through membranes in dialysis machines and directly induce oxidant damage to red blood cells?
- A. Chloramine                      C. Ammonia and chlorine compounds  
B. Dichloramine                      D. None of the above

### Chloramine Section

165. \_\_\_\_\_:  $\text{NH}_3 + \text{HOCl} \rightarrow \text{NH}_2\text{Cl} + \text{H}_2\text{O}$
- A. Free chlorine                      C. Monochloramine  
B. Dichloramine                      D. None of the above

166. Which of the following terms are formed in the pH range of 4.5 to 8.5, however, monochloramine is most common when the pH is above 8?
- A. Trichloramine                      C. Monochloramine and dichloramine  
B. Dichloramine                      D. None of the above

### Post Chlorination

167. Post chlorination is almost always done in water treatment, but can be replaced with chlorine dioxide or chloramines. In this stage, chlorine is fed to the drinking water stream that is then sent to the chlorine contact basin to allow the chlorine a long enough detention time to kill all viruses, bacteria, and protozoa that were not removed and rendered inactive in the prior stages of treatment.
- A. True                      B. False

### Understanding Water Disinfection

#### Wastewater Disinfection

168. There are several chemicals and processes that will \_\_\_\_\_, but none are universally applicable as with chlorine.
- A. Limit the effects of organic material                      C. Disinfect wastewater  
B. Limit the travel of pathogens                      D. None of the above

### Chloride Ion

169. Which of the following terms is also a useful and reliable chemical indicator of river / groundwater fecal contamination, as chloride is a non-reactive solute and ubiquitous to sewage & potable water?

- A. Chlorate
- B. Chloride
- C. Chlorine dioxide
- D. None of the above

### Chlorite Ion

170. Chlorine can assume an additional oxidation state of +4 is seen in the neutral compound \_\_\_\_\_, which has a similar structure to chlorite  $\text{ClO}_2^-$  and the cation chloryl.

- A. Chlorine dioxide  $\text{ClO}_2$
- B. Chloride
- C. Chlorite ion of  $\text{ClO}_2^-$
- D. None of the above

### Chlorine Dioxide

171. Chlorine dioxide is a chemical compound with which formula?

- A.  $\text{CaCl}_2$
- B.  $\text{ClO}$
- C.  $\text{ClO}_2$
- D. None of the above

### Haloacetic Acids

172. What type of substances are haloacetic acids in which a halogen atom takes the place of a hydrogen atom in acetic acid?

- A. Calcemic acids
- C. Carboxylic acids
- B. Hypochlorite acids
- D. None of the above

### Chloroform

173. Chloroform is typically the most prevalent \_\_\_\_\_ measured in chlorinated water, is probably the most thoroughly studied disinfection byproduct.

- A. HAA5
- B. THM
- C. Folic Acid
- D. None of the above

### Chloramines

174. What are chemical compounds formed by combining a specific ratio of chlorine and ammonia in water?

- A. Disinfection byproducts
- B. Chloramines
- C. Trihalomethanes, haloacetic acids, bromate, and chlorite
- D. None of the above

### Chlorine Dioxide

175. Chlorine dioxide ( $\text{ClO}_2$ ) represents a compound that may be generated on-site at water treatment facilities.

- A. True
- B. False

176. Chlorine dioxide characteristics are quite different from \_\_\_\_\_. In solution, it is a dissolved gas, which makes it largely unaffected by pH but volatile and relatively easily stripped from solution.

- A. Chlorine
- B. Sodium hypochlorite
- C. Carbon dioxide
- D. None of the above

177. \_\_\_\_\_ is also a strong disinfectant and a selective oxidant. While chlorine dioxide does produce a residual, it is only rarely used for this purpose.

- A. Chlorine dioxide
- B. Sodium hypochlorite
- C. Carbon dioxide
- D. None of the above

## Safety and Chlorination Equipment Section

### Chlorination Equipment Requirements

178. Which of the following shall also be located inside the chlorine room?

- A. Gas vacuum line
- B. Vacuum regulators
- C. Mechanical gas proportioning equipment
- D. None of the above

179. Which of the following shall have positive shutdown in the event of a break in the downstream vacuum lines?

- A. Gas vacuum line
- B. The vacuum regulating valve(s)
- C. A gas pressure relief system
- D. None of the above

### Capacity

180. Which of the following shall have the capacity to dose enough chlorine to overcome the demand and maintain the required concentration of the "free" or "combined" chlorine?

- A. The chlorinator
- B. Automatic proportional control
- C. Constant pre-established dosage
- D. None of the above

### Methods of Control

181. Which of the following shall be automatic proportional controlled, automatic residual controlled, or compound loop controlled?

- A. A chlorine feed system
- B. Constant flow rate(s)
- C. Constant pre-established dosage
- D. None of the above

### Standby Provision

182. As a safeguard against \_\_\_\_\_, standby chlorination equipment having the capacity to replace the largest unit shall be provided.

- A. Uninterrupted chlorination
- B. Constant flow rate(s)
- C. Malfunction and/or shut-down
- D. None of the above

183. All chlorine cylinders shall be securely positioned to safeguard against movement. Tag the cylinder "empty" and store flat and chained. Ton containers may be stacked.

- A. True
- B. False

184. Leak detection equipment shall not automatically activate the chlorine room ventilation system in such a manner as to discharge chlorine gas.

- A. True
- B. False

185. During an emergency, if the chlorine room is occupied, the chlorine gas leakage shall be contained within the chlorine room itself in order to facilitate a proper method of clean-up.

- A. True
- B. False

186. Consideration should also be given to the provision of caustic soda solution reaction tanks for absorbing the contents of leaking one-ton cylinders where such cylinders are in use.

- A. True
- B. False

## Alternative Disinfection Section

### Chlorine Dioxide Section

187. ClO<sub>2</sub> generation uses \_\_\_\_\_ and chlorine gas.

- A. Sodium chlorite (NaClO<sub>2</sub>)
- B. Hypochlorous acid
- C. Ozone
- D. None of the above

### Ultraviolet Disinfection

188. The microorganisms spend maximum time and contact with the outside of the quartz tube and the source of the?

- A. UV rays
- B. Radiation
- C. Electromagnetic energy
- D. None of the above

189. The basic design flow of water of certain UV units is in the order of \_\_\_\_\_ for each inch of the lamp, the units are designed so that the contact or retention time of the water in the unit is not less than \_\_\_\_\_.

- A. 20 gpm - 15 seconds
- B. 2.0 gpm - 100 seconds
- C. 2.0 gpm - 15 seconds
- D. None of the above

190. A disinfection process involves exposing water to \_\_\_\_\_, which inactivates various microorganisms. The technique has enjoyed increased application in wastewater treatment but very limited application in potable water treatment.

- A. Sterilizer
- B. Electromagnetic energy
- C. Ultraviolet (UV) radiation
- D. None of the above

191. In UV, quartz is often used in this case since practically none of the UV rays are absorbed by the quartz, \_\_\_\_\_ cannot be used since it will absorb the UV rays, leaving little for disinfection.

- A. Carbon
- B. Ozone
- C. Ordinary glass
- D. None of the above

### Strongest Oxidizing Agent

192. Which compound is obtained by passing a flow of air or oxygen between two electrodes that are subjected to an alternating current in the order of 10,000 to 20,000 volts?

- A. Liquid Ozone
- B. Ozone
- C. O<sub>2</sub>
- D. None of the above

193. Ozone has a \_\_\_\_\_ similar to that sometimes noticed during and after heavy electrical storms. In use, ozone breaks down into oxygen and nascent oxygen.

- A. Self-policing pungent odor
- B. H<sub>2</sub>S odor
- C. Pleasant odor of rain
- D. None of the above

194. Ozone does not form chloramines or \_\_\_\_\_, and while it may destroy some THMs, it may produce others when followed by chlorination.

- A. Carcinogens
- B. THMs
- C. Oxygen and nascent oxygen
- D. None of the above

195. Ozone falls into the same category as other disinfectants in that it can produce?

- A. Carcinogens
- B. DBPs
- C. Oxygen and nascent oxygen
- D. None of the above

196. It is the nascent oxygen that produces the high oxidation and disinfections, and even sterilization. Each water has its own \_\_\_\_\_, in the order of 0.5 ppm to 5.0 ppm. Contact time, temperature, and pH of the water are factors to be determined.

- A. Nascent oxygen
- B. THMs
- C. Ozone demand
- D. None of the above

197. When determining Ozone CT (contact time) values must be determined for the ozone basin alone; an accurate \_\_\_\_\_ must be obtained for the contact chamber, and residual levels.

- A. Residual
- C. Contact time
- B. T10 value
- D. None of the above

198. Ozone does not provide a system residual and should be used as a primary disinfectant only in conjunction with?

- A. Dry sodium chlorite
- C. Free and/or combined chlorine
- B. Chlorine dioxide
- D. None of the above

### **Alternate Disinfectants Section Summary**

#### **Chlorine Dioxide**

199. Which term provides good Giardia and virus protection but its use is limited by the restriction on the maximum residual of 0.5 mg/L  $\text{ClO}_2$ /chlorite/chlorate allowed in finished water?

- A. Chlorinated byproducts
- C. Ammonia residual(s)
- B. Chlorine dioxide
- D. None of the above

#### **Chloramines**

200. It is recommended that chloramine be used in conjunction with a stronger disinfectant. It is best utilized as a?

- A. Chloramine
- C. Stable distribution system disinfectant
- B. T10 value disinfectant
- D. None of the above