

**Registration form**

**Disinfection Basics CEU Training Course \$200.00  
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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**Please circle/check which certification you are applying the course CEU's.**

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

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<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.*

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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.

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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.

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# Disinfection Basics CEU Course Answer Key

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

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

It is your sole responsibility 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? \_\_\_\_\_

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



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

**DISINFECTION BASICS 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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*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.*

## Disinfection Basics CEU Course Assignment

The Disinfection Basics 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.

### Preface

#### Disinfection Essentials

1. Safety: A system will often require significant safety protection—such as use of breathing apparatus and protective clothing—as well as high levels of operator training, it may be advisable to explore other,

- \_\_\_\_\_.
- A. Disinfectant systems
  - B. Narrow tolerances
  - C. Less intensive systems
  - D. None of the above

2. Environmental/Adverse Effects: Some systems may need to have additional treatment of the disinfected effluent in order to render it benign when released, while other systems may provide a net-positive environmental benefit through increased?

- A. Operating costs
- B. Safeguards
- C. Oxygenation of the receiving waters
- D. None of the above

3. Flow and Water Characteristics: If your system cannot correct for dry or wet weather flow rates of the receiving water body, \_\_\_\_\_ may also affect the system's appropriateness for your application.

- A. Off-site concerns
- B. Narrow tolerance
- C. Net-positive environmental benefit
- D. None of the above

4. Selecting the right \_\_\_\_\_ requires understanding several factors governing the particular site and the water or wastewater to be treated.

- A. Operating method
- B. Disinfection weapon
- C. Net-positive environmental benefit
- D. None of the above

5. Other than chlorine, there are primarily four basic disinfection systems currently available—chlorination, ozone gas, ultraviolet radiation, and Chemical treatment.

- A. True
- B. False

6. An operator of an onsite water or wastewater treatment plant needs to consider some of the safeguards that need to be in place as well. One decision to install a system could be the result of local concerns and potential to mitigate health risks, as well as?

- A. Improved community relations
- B. Narrow tolerance
- C. Net-positive environmental benefit
- D. None of the above

## Safety and Chlorination EquipmentSection

### Chlorination Equipment Requirements

7. Which of the following shall be included in the gas vacuum line between the vacuum regulator(s) and the chlorinator(s) to ensure that pressurized chlorine gas does not enter the gas vacuum lines leaving the chlorine room?
- A. Gas vacuum line                      C. Mechanical gas proportioning equipment  
B. A gas pressure relief system        D. None of the above
8. Which of the following shall have positive shutdown in the event of a break in the downstream vacuum lines?
- A. Gas vacuum line                      C. A gas pressure relief system  
B. The vacuum regulating valve(s)    D. None of the above
9. Anti-siphon valves shall be incorporated in the \_\_\_\_\_ or in the discharge piping.
- A. Gas vacuum line                      C. Pump heads  
B. A gas pressure relief system        D. None of the above
10. Which of the following, which is the mechanical gas proportioning equipment, may or may not be located inside the chlorine room?
- A. Gas vacuum line                      C. The chlorinator  
B. Compound loop                        D. None of the above
11. Which of the following shall also be located inside the chlorine room?
- A. Gas vacuum line                      C. Mechanical gas proportioning equipment  
B. Vacuum regulators                    D. None of the above
12. \_\_\_\_\_ should be located to minimize the length of pressurized chlorine solution lines.
- A. Gas vacuum line                      C. Mechanical gas proportioning equipment  
B. Injectors                                D. None of the above

### Capacity

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

### Methods of Control

14. Which of the following shall be automatic proportional controlled, automatic residual controlled, or compound loop controlled?
- A. A chlorine feed system                C. Constant pre-established dosage  
B. Constant flow rate(s)                 D. None of the above
15. Which piece of chlorination equipment adjusts the chlorine feed rate automatically in accordance with the flow changes to provide a constant pre-established dosage for all rates of flow?
- A. Manual chlorine feed valve            C. Automatic proportional control  
B. Constant flow rate(s)                 D. None of the above

16. Which piece of chlorination equipment is the feed rate of the chlorinator controlled by a flow proportional signal and a residual analyzer signal to maintain particular chlorine residual in the water?  
A. Manual chlorine feed systems    C. Mechanical gas proportioning equipment  
B. Compound loop control system    D. None of the above
17. Manual chlorine feed systems may be installed for groundwater systems with constant flow rates.  
A. True    B. False
18. Chlorine gas under pressure shall not be permitted outside the chlorine room.  
A. True    B. False

### **Standby Provision**

19. 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
20. 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
21. 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
22. Chlorine leak detection equipment may not be required for very small chlorine rooms with an exterior door (e.g., floor area less than 3m<sup>2</sup>).  
A. True    B. False
23. You can use a spray solution of sulfur dioxide or a rag soaked with sulfur dioxide to detect a small Cl<sub>2</sub> leak. If there is a leak, the sulfur dioxide will create a white colored smoke - sulfuric chloride.  
A. True    B. False
24. Scales for weighing cylinders shall be provided at all plants using chlorine gas to permit an accurate reading of total daily weight of chlorine used. At large plants, scales of the recording and indicating type are recommended. As a minimum, a platform scale shall be provided. Scales shall be of corrosion-resistant material.  
A. True    B. False
25. 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
26. Which of the following chlorine alarm equipment shall be installed at all water treatment plants using chlorine gas?  
A. Caustic soda solution reaction alarms    C. Automatic chlorine leak detection  
B. Corrosion detection    D. None of the above
27. Which of the following related chlorine alarm equipment should be connected to a remote audible and visual alarm system and checked on a regular basis to verify proper operation?  
A. Chlorine gas leakage alarm    C. Chlorine leak detection equipment  
B. All chlorine cylinders    D. None of the above

28. 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

29. For uninterrupted chlorination, \_\_\_\_\_ shall be equipped with an automatic changeover system. In addition, spare parts shall be available for all chlorinators.

- A. Flow valves
- B. Flow regulators
- C. Gas chlorinators
- D. None of the above

### Chlorine Room Design Requirements

30. \_\_\_\_\_ should be louvered near the ceiling, the air being of such temperature as to not adversely affect the chlorination equipment.

- A. Air inlets
- B. Ventilation system
- C. Automatic chlorine leak detection
- D. None of the above

31. \_\_\_\_\_ should be outside the room at all entrance or viewing points and a clear wire-reinforced glass window shall be installed in such a manner as to allow the operator to inspect from the outside of the room.

- A. Separate switches for fans and lights
- B. Chlorine room ventilation system
- C. Automatic chlorine leak detection
- D. None of the above

32. Chlorine rooms shall have \_\_\_\_\_, if a forced air system is used to heat the building.

- A. Corrosion filters
- B. Separate heating systems
- C. Cooling system
- D. None of the above

33. Where gas chlorination is practiced, the gas cylinders and/or the ton containers up to the vacuum regulators shall be housed in a gas-tight, well illuminated, corrosion resistant and \_\_\_\_\_ ventilated enclosure.

- A. Mechanically
- B. Securely positioned
- C. Automatic chlorine leak detection
- D. None of the above

34. \_\_\_\_\_ may or may not be located inside the chlorine room.

- A. The chlorinator
- B. All chlorine cylinders
- C. Chlorine leak detection equipment
- D. None of the above

35. Which of the following shall have entirely separate exhaust ventilation systems capable of delivering one (1) complete air change per minute during periods of chlorine room occupancy only?

- A. Shut off
- B. The chlorine room
- C. Automatic chlorine leak detection
- D. None of the above

36. \_\_\_\_\_ shall be protected to ensure that the chlorine maintains its gaseous state when entering the chlorinator.

- A. Cylinders or containers
- B. Panic system
- C. Equipment
- D. None of the above

### Storage of Chlorine Cylinders

37. The chlorine cylinder storage room shall have access either to the chlorine room or from the plant exterior, and arranged to prevent the uncontrolled release of spilled gas.

- A. True
- B. False

38. Which chlorine safety related equipment term shall have provision for ventilation at thirty air changes per hour?

- A. Cylinders or containers access
- B. Scrubber(s)
- C. The chlorine gas storage room
- D. None of the above

39. In very large facilities, entry into the chlorine rooms may be through a \_\_\_\_\_.

- A. Vestibule from inside
- B. Chlorine gas storage room
- C. Vestibule from outside
- D. None of the above

### Scrubbers

40. Which term means the amount of chlorine required to produce a residual of 0.1 mg/l after a contact time of fifteen minutes as measured by Iodometric method of a sample at a temperature of twenty degrees in conformance with Standard methods?

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

41. Facilities located within residential or densely populated areas, consideration shall be given to provide \_\_\_\_\_ for the chlorine room.

- A. Plan of attack
- B. Scrubber(s)
- C. Chlorine dozing plan
- D. None of the above

42. Chlorine combines with a wide variety of materials. These side reactions complicate the use of chlorine for disinfecting purposes, their \_\_\_\_\_ must be satisfied before chlorine becomes available to accomplish disinfection.

- A. Combined residual
- B. Free chlorine residual
- C. Demand for chlorine
- D. None of the above

### Chlorine Health Hazard Section

43. Which term expresses low levels of chlorine results in eye, nose, and throat irritation, sneezing, Excessive salivation, general excitement, and restlessness?

- A. Rambling
- B. Acute exposure
- C. Chronic exposure
- D. None of the above

44. Which term expresses low levels of chlorine gas can result in a dermatitis known as chloracne, tooth enamel corrosion, coughing, sore throat, hemoptysis and increased susceptibility to tuberculosis?

- A. Rambling
- B. Acute exposure
- C. Chronic exposure
- D. None of the above

### Inhalation

45. If you get chlorine in the eye, pour a gentle stream of \_\_\_\_\_ through the affected eye for at least 15 minutes. Contact the poison control center, emergency room or physician right away as further treatment will be necessary.

- A. Salt water
- B. Warm water
- C. Milk
- D. None of the above

46. If you get chlorine on the skin, run \_\_\_\_\_ over the affected area for 15 minutes.

- A. A gentle stream of water
- B. Warm water
- C. Cold water
- D. None of the above

47. Which term expresses coughing, sneezing, shortness of breath, sensation of tightness in the chest, as well as severe restlessness or Anxiety, nausea, and vomiting?

- A. Inhalation
- B. Acute exposure
- C. Chronic exposure
- D. None of the above

48. The nose and throat may become irritated; a stinging and Burning sensation may be experienced. Immediate fatalities can occur as a result of suffocation. Delayed fatalities can occur as a result of pulmonary edema (fluid in the lungs). For this reason, rest and immediate attention after inhalation is important.

- A. True
- B. False

49. If breathing has stopped, give artificial respiration; if breathing is difficult, give oxygen if equipment and trained personnel are available. If exposed person is breathing, place in a comfortable position and keep person warm and at rest until medical assistance becomes available.

- A. True
- B. False

50. Liquid and concentrated gas will produce severe burns and injury on contact.

- A. True
- B. False

### **Pre-hospital Management**

51. Rescue personnel are at low risk of noncardiogenic pulmonary edema contamination from victims who have been exposed only to gases released from hypochlorite solutions. However, clothing or skin soaked with industrial-strength bleach or similar solutions may be corrosive to rescuers and may release harmful gases.

- A. True
- B. False

52. Ingestion of hydrochlorite solutions rarely causes pain in the mouth or throat, dysphagia, stridor, drooling, odynophagia, and vomiting.

- A. True
- B. False

53. Chronic exposure to gases released from ammonia solutions can cause coughing, eye and nose irritation, lacrimation, and a burning sensation in the chest.

- A. True
- B. False

### **Rescuer Protection**

54. Hypochlorite is irritating to the skin and eyes and in some cases may release toxic gases.

- A. True
- B. False

55. Positive-pressure, self-contained breathing apparatus (SCBA) is recommended in response to situations that involve exposure to potentially unsafe levels of Chlorine gas.

- A. True
- B. False

56. Chemical-protective clothing is not necessary for direct contact with solid hypochlorite or concentrated solutions.

- A. True
- B. False

### **Hot Zone**

57. Which term is the area that rescuers should be trained and appropriately attired before entering?

- A. Support Zone
- B. Hot Zone
- C. Decontamination area
- D. None of the above



### ABC Reminders

58. If a person is over taken with chlorine gas exposure, quickly establish a \_\_\_\_\_, ensure adequate respiration and pulse.
- A. Support Zone
  - B. Patient airway
  - C. Decontamination Zone
  - D. None of the above

### Victim Removal

59. During the chlorine evacuation, if victims can walk, lead them out of the?
- A. Decontamination area
  - B. Hot Zone
  - C. Hot Zone to the Decontamination Zone
  - D. None of the above
60. Victims may be transferred immediately to the \_\_\_\_\_. All others require decontamination.
- A. Support Zone
  - B. Patient Zone
  - C. Chemical free zone
  - D. None of the above

## Alternative Disinfection Section

### Chlorine Dioxide Section

61. 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
62. Chlorine gas is educted into a motive water stream in a ClO<sub>2</sub> generator forming?
- A. HOCl and HCl
  - B. Chlorine dioxide
  - C. Sodium thiosulfate
  - D. None of the above
63. Which compound is pumped into the stream and allowed to react in a generating column to produce ClO<sub>2</sub>?
- A. Hypochlorous acid
  - B. Chlorine dioxide
  - C. Sodium chlorite
  - D. None of the above
64. Which of the following compound(s) does not hydrolyze in water as chlorine does and with it, no dissociation of ClO<sub>2</sub>?
- A. Chlorine gas
  - B. Chlorine dioxide or ClO<sub>2</sub>
  - C. NaOCl and HCl
  - D. None of the above
65. Which of the following compound(s) remains a gas in water, it does not have the corrosive tendencies of chlorine gas?
- A. Sodium chlorite (NaClO<sub>2</sub>)
  - B. Chlorine dioxide or ClO<sub>2</sub>
  - C. Sodium chlorate (NaClO<sub>3</sub>)
  - D. None of the above
66. Which of the following compound(s) is a dissolved gas in water; there is no mineral acid or caustic soda formation as happens when using HOCl.
- A. ClO<sub>2</sub>
  - B. NaClO<sub>2</sub>
  - C. NaOCl and HCl in place of chlorine gas
  - D. None of the above
67. Which of the following compound(s) tends to be much less, if not totally non-reactive, with many organic and inorganic compounds.
- A. ClO<sub>2</sub>
  - B. Hypochlorous acid
  - C. Sodium chlorite (NaClO<sub>2</sub>)
  - D. None of the above



78. 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                      C. Ordinary glass  
B. Ozone                        D. None of the above
79. The \_\_\_\_\_ will consist of a various number of lamps and tubes, depending upon the quantity of water to be treated.
- A. UV sterilizer                C. UV reactor  
B. Electromagnetic energy    D. None of the above
80. Ensuring that the \_\_\_\_\_ maintains good contact with the water requires control of the water level within the channel to ensure that the UV is making total contact at the designed depths.
- A. UV                              C. Channel  
B. Ballasts and shields        D. None of the above
81. Heat is generated by the electric components of the UV system, adequate ventilation and cooling must be applied to the \_\_\_\_\_ to reduce heat build-up, otherwise the ballasts could fail.
- A. UV arrays                    C. UV reactor  
B. Electromagnetic energy    D. None of the above
82. Because of the great electrical consumption of this system, combined with the cost of routine replacement of \_\_\_\_\_, should be considered against other systems.
- A. UV capacitor                C. Ballasts and shields  
B. UV Flux                      D. None of the above
83. The germicidal effect of UV is thought to be associated with its reduction by various inorganic components essential to the cell's functioning.
- A. True                          B. False
84. The contact time for the wastewater with the UV source is the shortest of any of the disinfectant strategies, lasting no longer than 20 to 30 seconds.
- A. True                          B. False
85. Disadvantages include the effects of turbidity in the water reducing the infiltration and therefore the effectiveness of ballasts and shields and the need to provide an effective cleaning and replacement program for the UV components.
- A. True                          B. False
86. The effective use of ultraviolet treatment, the water to be disinfected can contain suspended solids. The water does not need to be colorless and can contain colloids, iron, manganese, taste, and odor.
- A. True                          B. False
87. Which term represents the transfer of electromagnetic energy from a mercury arc lamp to a pathogen's DNA material, thus affecting its ability to replicate itself?
- A. Transfer                      C. Electromagnetic energy  
B. UV disinfection              D. None of the above

88. Which term represents the intensity being emitted, the length of time that the wastewater comes in contact with the UV radiation, and the arrangement of the UV reactor?
- A. UV radiation
  - B. Disinfection
  - C. CT
  - D. None of the above

**Strongest Oxidizing Agent**

89. 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

90. Ozone is a \_\_\_\_\_ gas at room temperature.
- A. Reddish
  - B. Yellowish
  - C. Light blue
  - D. None of the above

91. 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
  - C. Pleasant odor of rain
  - B. H<sub>2</sub>S odor
  - D. None of the above

92. 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

93. 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

94. 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

95. Liquid Ozone is very unstable and can readily explode. As a result, it is not shipped and must be manufactured on-site.
- A. True
  - B. False

96. Ozone is a very effective disinfectant for both Giardia and viruses
- A. True
  - B. False

97. Ozone does not produce chlorinated byproducts (such as trihalomethanes) but it may cause an increase in such byproduct formation if it is fed ahead of free chlorine; ozone may also produce its own oxygenated byproducts such as Cl<sub>2</sub> + NH<sub>4</sub>.
- A. True
  - B. False

98. Ozonation must include adequate ozone leak detection alarm systems, and an ozone off-gas destruction system.
- A. True
  - B. False

99. 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
- B. T10 value
- C. Contact time
- D. None of the above

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

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

### Alternate Disinfectants Section Summary

#### Chloramines

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

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

102. In the production of \_\_\_\_\_, the ammonia residuals in the finished water, when fed in excess of stoichiometric amount needed, should be limited to inhibit growth of nitrifying bacteria.

- A. Dry sodium chlorite
- B. Chloramines
- C. Ammonia residual(s)
- D. None of the above

#### Chlorine Dioxide

103. 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 ClO<sub>2</sub>/chlorite/chlorate allowed in finished water?

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

104. If chlorine dioxide is being used as an oxidant, the preferred method of generation is to entrain this term or substance into a packed reaction chamber with a 25% aqueous solution of sodium chlorite (NaClO<sub>2</sub>).

- A. Chloramine
- B. Chlorine gas
- C. Chlorine dioxide
- D. None of the above

105. According to the text, which chemical is explosive and can cause fires in feed equipment if leaking solutions or spills are allowed to dry out?

- A. Dry sodium chlorite
- B. Chlorine dioxide
- C. Ammonia
- D. None of the above

106. Chlorine dioxide may be used for either taste or odor control or as a?

- A. Chloramine
- B. Pre-disinfectant
- C. Gas
- D. None of the above

107. Total residual oxidants (including chlorine dioxide and chlorite, but excluding Chlorine dioxide) shall not exceed 0.50 mg/L during normal operation or 0.30 mg/L (including chlorine dioxide, chlorite and chlorate) during periods of extreme variations in the raw water supply.

- A. True
- B. False

## Ozone

108. Ozone does not provide a system residual and should be used as a primary disinfectant only in conjunction with free and/or combined chlorine.

- A. True      B. False

109. Ozone may also be used as \_\_\_\_\_ for removal of taste and odor, or may be applied as a pre-disinfectant.

- A. An oxidant      C. System residual  
B. Reducer      D. None of the above

110. Which term must be determined for the ozone basin alone; an accurate T10 value must be obtained for the contact chamber, residual levels measured through the chamber and an average ozone residual calculated?

- A. Ozone CT (Contact time)      C. Free and/or combined chlorine  
B. Residual levels      D. None of the above

## Chlorine Section

### Chlorine Gas Appearance and Odor

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

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

112. 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      C. Olfactory fatigue  
B. Odor thresholds      D. None of the above

### Reactivity

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

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

114. 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      C. Moisture, steam, and water  
B. Odor thresholds      D. None of the above

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

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

116. Chlorine is also incompatible with?

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

117. Contact between chlorine and arsenic, bismuth, boron, calcium, activated carbon, carbon disulfide, glycerol, hydrazine, iodine, methane, oxomonosilane, potassium, propylene, and silicon should be avoided.  
A. True      B. False

### Flammability

118. When there is a fire that involves chlorine, the firefight should be fought downwind from the minimum distance possible.  
A. True      B. False

119. Keep unnecessary people away; isolate the hazard area and deny entry. For a massive fire in a cargo area, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from the area and let the fire burn. Emergency personnel should stay out of low areas and ventilate closed spaces before entering.  
A. True      B. False

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

120. When chlorine is released to soil, chlorine will react with moisture forming free unstable oxygen radicals.  
A. True      B. False

121. 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

122. The hydrochloric acid will raise the pH of the water (makes it more basic).  
A. True      B. False

### Chlorine Exposure Limits

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

124. 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

125. 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

126. 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

127. Cl<sub>2</sub> IDLH is?  
A. 10 PPM      C. 1,000 PPM  
B. 0.1 PPM      D. None of the above

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

129. OSHA PEL is?  
A. 10 PPM    C. 1,000 PPM  
B. 1 PPM    D. None of the above

### Disinfectant Qualities

130. 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

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

132. 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

133. 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

134. 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

135. 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

136. 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

137. 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



138. 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 (OCI-).
- A. HCl            C. The hypochlorate ion (OCI-)  
 B. HOCl         D. None of the above
139. In alkaline conditions, \_\_\_\_\_ becomes the predominant species and lacks the biocidal efficacy of the non-dissociated form.
- A. HCl            C. OCI-  
 B. HOCl         D. None of the above
140. Considerably more \_\_\_\_\_ is present at a pH of 7.0 than at pH 8.5.
- A. HCl            C. OCI-  
 B. HOCl         D. None of the above
141. 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
142. 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 (OCI-)            D. None of the above
143. 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
144. 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
145. 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
146. 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

## Chlorine Gas

### Pathophysiology

147. 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
- B. Vapor from Chlorine gas
- C. Water solubility
- D. None of the Above

148. Respiratory exposure to \_\_\_\_\_ may be prolonged because its moderate water solubility may not cause upper airway symptoms for several minutes.

- A. Hydrochloric acid
- B. Chlorine gas
- C. Plasma exudation
- D. None of the Above

149. The odor threshold for chlorine gas is approximately?

- A. 0.3-0.5 parts per million (ppm)
- B. 3 parts per million (ppm)
- C. 3-5 parts per million (ppm)
- D. None of the Above

### Mechanism of Activity

150. 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
- B. Chlorine acid
- C. Hypochlorous and hydrochloric acid
- D. None of the above

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

- A. True
- B. False

152. 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

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

- A. Hydrochloric acid
- B.  $H_2SO_4$
- C. Hypochlorous base
- D. None of the above

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

- A. Hydrochloric acid
- B.  $H_2SO_4$
- C. Ozone
- D. None of the above

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

- A. Hydrochloric acid
- B.  $H_2SO_4$
- C. Hypochlorous acid
- D. None of the above

### Early Response to Chlorine Gas

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

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

157. 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

158. Chlorine is a highly reactive gas.  
A. True      B. False

159. 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

160. 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

161. 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

162. 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

163. 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

164. 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

165. 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

166. Chlorination is more effective as?  
A. Water temperature increases      C. Water cools down  
B. Chlorine demand increases      D. None of the above

167. 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
168. Chlorination is less effective in?  
 A. Clear water      C. Day time  
 B. Cloudy (turbid) water      D. None of the above
169. 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**

170. Chlorine disinfectants can lower the level of many disease-causing microorganisms in drinking water to almost immeasurable levels.  
 A. True      B. False
171. 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

172. One pound of elemental chlorine delivers approximately as much \_\_\_\_\_ as one gallon of sodium hypochlorite (12.5% solution) or approximately 1.5 pounds of calcium hypochlorite (65% strength).  
 A. Free available chlorine      C. Particular applications  
 B. Total chlorine      D. None of the above

173. While any of these forms of chlorine can effectively disinfect drinking water, each has distinct advantages and limitations for \_\_\_\_\_. Almost all water systems that disinfect their water use some type of chlorine-based process, either alone or in combination with other disinfectants.  
 A. Free available chlorine      C. Particular applications  
 B. Total chlorine      D. None of the above

**Taste and Odor Control**

174. 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**

175. 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

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

### Chemical Control

176. 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
- B. Algae secretions
- C. Slime bacteria, molds and algae
- D. None of the above

### Water Treatment

177. 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
- B. Sediments
- C. Chemical or biological contamination
- D. None of the above

178. Surface water typically presents a greater treatment challenge than groundwater, which is naturally filtered as it percolates through?

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

179. Surface water is generally safe unlike groundwater that may harbor protozoan parasites such as *Cryptosporidium parvum* and *Giardia lamblia*.

- A. True
- B. False

180. Everyday, about 170,000 PWSs treat and convey billions of gallons of water through about 880,000 miles of distribution system piping to U.S. homes, farms and businesses.

- A. True
- B. False

### Water Distribution

181. Chlorination is unique in that a pre-determined chlorine concentration may be designed to remain in treated water as a measure of protection against harmful microbes encountered after leaving the treatment facility.

- A. True
- B. False

182. 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
- B. Potential threats
- C. Breakpoint Chlorination
- D. None of the above

### The Challenge of Disinfection Byproducts

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

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

184. While the available evidence does not prove that \_\_\_\_\_ in drinking water cause adverse health effects in humans, high levels of these chemicals are certainly undesirable. Cost-effective methods to reduce DBP formation are available and should be adopted where possible.

- A. Critical assets
- B. DBPs
- C. Vulnerability assessments
- D. None of the above

### Chlorine and Water System Security

185. The prospect of a terrorist attack has forced all water systems, large and small, to re-evaluate and upgrade chlorination effectiveness procedures.

- A. True      B. False

186. These treatment chemicals are both inert and potential barriers.

- A. True      B. False

187. 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

188. 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      C. Critical assets  
B. Potential threats      D. None of the above

189. Which of the following in no way guarantees safety from biological attacks?

- A. Inert and potential barriers      C. Conventional treatment barriers  
B. Potential problems      D. None of the above

### Chlorination Chemistry

190. The disassociation of chlorine gas

(OCI - ):  $\text{HOCl} \rightarrow \text{H}^+ + \text{OCI}^-$  Also expressed  $\text{HOCl} \rightarrow \text{H}^+ + \text{OCI}^-$   
(hypochlorous acid) (hydrogen) (hypochlorite ion)

- A. True      B. False

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

- A. True      B. False

192. 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

193. The hypochlorite ion is a much weaker disinfecting agent than Hypochlorous acid, about 100 times less effective.

- A. True      B. False

194. Under normal water conditions, hypochlorous acid will also chemically react and break down into the hypochlorite ion.

- A. True      B. False

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

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

196. Temperature plays a small part in the acid ratio. Although the ratio of \_\_\_\_\_ is greater at lower temperatures, pathogenic organisms are actually harder to kill.

- A. Hypochlorous acid
- B. Chlorine Demand
- C. Total chlorine
- D. None of the above

197. If all other things were equal, \_\_\_\_\_ and a lower pH are more conducive to chlorine disinfection.

- A. Lower alkali
- B. Higher water temperatures
- C. Lower water temperature
- D. None of the above

### Types of Residual

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

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

199. 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

200. 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

201. Either a total or a \_\_\_\_\_ can be read when a chlorine residual test is taken,

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

202. 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

203. 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

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

204. 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

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

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

206. 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

207. The CT concept as developed by the United States Environmental Protection Agency (uses the combination of disinfectant residual concentration (mg/L) and the effective disinfection contact time (in minutes) to measure effective pathogen reduction.

- A. True
- B. False

**Calculation and Reporting of CT Data**

208. 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

209. 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

210. 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

211. 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

**Chlorine Review**

212. 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

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

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

214. What term describes the concentration of residual chlorine in water present as dissolved gas (Cl<sub>2</sub>), hypochlorous acid (HOCl), and/or hypochlorite ion (OCI-)?

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

215. 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



216. \_\_\_\_\_ is defined as the residual chlorine existing in water in chemical combination with ammonia or organic amines which can be found in natural or polluted waters.
- A. Chlorine Residual                      C. Combined Chlorine  
B. Chlorine Demand                        D. None of the above
217. What term describes 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 Demand                        C. Residual chlorine  
B. Combined Chlorine Residual        D. None of the above
218. Which of the following terms of at least 1.0 mg/L should be maintained in the clear well or distribution reservoir immediately downstream from the point of post-chlorination and .2 mg/L in the distribution system to guard against backflow?
- A. Chlorine Demand                        C. Free chlorine residual  
B. Chlorine total                            D. None of the above
219. What term describes the total of free residual and combined residual chlorine in a water purification system; and used as a monitoring measurement by system operators?
- A. Chlorine Demand                        C. Total combined chlorine  
B. Total Chlorine Residual            D. None of the above
220. What term describes the total chlorine is essentially equal to free chlorine since the concentration of ammonia or organic nitrogen compounds will be very low? When chloramines are present in the municipal water supply, then total chlorine will be higher than free chlorine.
- A. Chlorine Demand                        C. Total chlorine  
B. Combined chlorine                    D. None of the above
221. When changing the Cl<sub>2</sub> cylinder, clean with wire brush if necessary. If the valve face is smooth, clean proceed with hooking up the cylinder. Check the inlet face of the \_\_\_\_\_ and clean if necessary.
- A. Fusible plug                              C. Chlorinator  
B. Chlorine cylinder                      D. None of the above
222. What is the best term that describes chlorine addition of chlorine at the plant headworks or prior to other water treatment or groundwater production processes and mainly used for disinfection and control of tastes, odors, and aquatic growth?
- A. Post-chlorination                        C. Pre-chlorination  
B. Chlorine Demand                        D. None of the above
223. What term best describes the sum of free and combined chlorine?
- A. Disinfection                              C. Total Chlorine  
B. Free chlorine                              D. None of the above
224. When chlorinating most potable water supplies, total chlorine is essentially equal to \_\_\_\_\_ since the concentration of ammonia or organic nitrogen compounds (needed to form combined chlorine) will be very low.
- A. The amount of chlorine                C. Free chlorine  
B. Chlorine Demand                        D. None of the above

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

225. What term best describes the residual chlorine existing in water in chemical combination with ammonia or organic amines that can be found in natural or polluted waters?

- A. Combined chlorine
- B. Free chlorine
- C. Breakpoint chlorination
- D. None of the above

226. Ammonia is sometimes deliberately added to chlorinated public water supplies to provide?

- A. Inorganic chloramines
- B. Chlorine Demand
- C. Increase pH value
- D. None of the above

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

- A. Disinfection
- B. Free chlorine
- C. Total chlorine residual
- D. None of the above

228. What term best describes the minimum amount of chlorine needed to react in a water purification system; used as a monitoring measurement by system operators?

- A. Chlorination
- B. Chlorine Demand
- C. Total chlorine
- D. None of the above

229. What term best describes the concentration of chlorine in the water after the chlorine demand has been satisfied?

- A. Chlorine Residual
- B. Free chlorine
- C. Breakpoint chlorination
- D. None of the above

230. \_\_\_\_\_ which includes both the free and combined or chemically bound chlorine residuals.

- A. Disinfection
- B. Free chlorine
- C. Total chlorine residual
- D. None of the above

231. What term best describes the addition of chlorine after a process or adding chlorine downstream to meet a Demand in the system?

- A. Post-chlorination
- B. Chlorine Demand
- C. Pre-chlorination
- D. None of the above

232. Solid chlorine is about 10 times heavier than water and gaseous chlorine is about 200 times heavier than air.

- A. True
- B. False

233. Atomic number of chlorine is 24.

- A. True
- B. False

234. Cl is the elemental symbol and  $\text{Cl}_2$  is the chemical formula.

- A. True
- B. False

### **Sodium Hypochlorite Exposure Exposure**

235. People are exposed to sodium hypochlorite by inhalation of aerosols. This causes coughing and a sore throat. After swallowing sodium hypochlorite, the effects are stomachache, a burning sensation, coughing, diarrhea, a sore throat and vomiting. Sodium hypochlorite on skin or eyes causes redness and pain.

- A. True
- B. False

236. After prolonged exposure, the skin can become sensitive. Sodium hypochlorite is poisonous for water organisms. It is mutagenic and very toxic when it comes in contact with Ammonium salts.  
A. True      B. False

### Routes of Exposure

#### Inhalation

237. Chlorine is lighter than air and may cause asphyxiation in poorly ventilated, enclosed, or high-lying areas.  
A. True      B. False
238. Which of the following can liberate toxic gases such as chlorine?  
A. Hypochlorite solutions      C. Ammonia  
B. Higher levels of O<sub>2</sub>      D. None of the above

#### Ingestion

239. Metabolic acidosis is rare, but has been reported following the ingestion of?  
A. Hypochlorous Acid (HOCl)      C. Sodium and calcium  
B. Household bleach      D. None of the above

#### Sources/Uses

240. Which compounds are manufactured by the chlorination of sodium hydroxide or lime?  
A. Sodium hypochlorite      C. Hypochlorite solutions, powder, or concentrated vapor  
B. Sodium and calcium hypochlorite      D. None of the above
241. Which compounds are used primarily as oxidizing and bleaching agents or disinfectants. They are components of commercial bleaches, cleaning solutions, and disinfectants for drinking water and waste water purification systems and swimming pools.  
A. Sodium hydroxide or lime      C. Sodium and calcium hypochlorite  
B. Hydrochlorite solutions      D. None of the above

#### Calcium Hypochlorite Section

242. 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
243. Sodium hypochlorite is generally available as a white powder, pellets, or flat plates; sodium hypochlorite is usually a greenish yellow, aqueous solution, although not flammable, they may react explosively.  
A. True      B. False
244. Calcium hypochlorite decomposes in water to release chlorine and oxygen; sodium hypochlorite solutions can react with acids or ammonia to release chlorine or chloramine.  
A. True      B. False

#### Description

245. Solid chlorine stands alone as the safest form of chlorine disinfection.  
A. True      B. False
246. 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

247. Because of solid chlorine, the elimination of costly scrubbers, containment, or hazard response capability, guarantees lower initial costs and reduced operating expense.

- A. True      B. False

248. Sodium hypochlorite is generally available as a white powder, pellets, or flat plates. It decomposes readily in water or when heated, releasing oxygen and chlorine. It has a strong chlorine odor, but odor may not provide an adequate warning of hazardous concentrations.

- A. True      B. False

249. Calcium hypochlorite is flammable, and acts as an oxidizer with combustible material and does not react explosively with ammonia, amines, or organic sulfides.

- A. True      B. False

### Effectiveness

250. Liquid chlorine can affect eyes, skin and mucous membranes; it is easily splashed and rots clothing.

- A. True      B. False

251. Hypochlorous Acid (HOCl) is much less corrosive than liquid chlorine, which is highly corrosive to most metals.

- A. True      B. False

252. Liquid Sodium hypochlorite and chlorine tablets produce Hypochlorous acid (HOCl) and?

- A. Calcium hypochlorite      C. Hypochlorite ion (OCl<sup>-</sup>) in solution  
B. Oxygen      D. None of the above

253. The ratio of Hypochlorous Acid to \_\_\_\_\_ increases with acidity.

- A. Calcium hypochlorite      C. Hypochlorite ion  
B. Hypochlorous Acid (HOCl)      D. None of the above

### Accuracy

254. Which compound's strengths vary so widely and are mostly unknown (the container usually says "less than 5%") that it is impossible to make up accurate in-use solutions without access to laboratory equipment?

- A. Liquid chlorine      C. Calcium hypochlorite  
B. Solid chlorine      D. None of the above

### Comparison

255. Which substance is comparable to sodium dichloroisocyanurate (NaDCC) is their neutralization by organic matter.

- A. Hypochlorous Acid      C. Sodium hypochlorite (NaOCl)  
B. Chloramine      D. None of the above

256. If there is a high concentration of organic material present, NaDCC will be very much more effective than?

- A. Calcium hypochlorite      C. NaOCl  
B. Oxygen and chlorine      D. None of the above

257. Hypochlorite powder, solutions, and vapors are irritating and corrosive to the eyes, skin, and respiratory tract.

- A. True      B. False

258. Ingestion and skin contact with hypochlorite powder, solutions, and vapors produces injury to any exposed tissues.

- A. True      B. False

259. Exposure to gases released from hypochlorite powder, solutions, and vapors may cause burning of the eyes, nose, and throat; cough as well as constriction and edema of the airway and lungs can occur.

- A. True      B. False

### **Sodium Hypochlorite Solutions**

260. Sodium hypochlorite solutions liberate the Toxic gases chlorine or chloramine if mixed with acid or ammonia (this can occur when bleach is mixed with another cleaning product). Thus, exposure to hypochlorite may involve exposure to these gases.

- A. True      B. False

### **Potential Sequelae**

261. Exposure to toxic gases generated from hypochlorite solutions can lead to reactive airways dysfunction syndrome (RADS), a chemical irritant-induced type of asthma.

- A. True      B. False

262. Chronic complications following ingestion of hypochlorite include esophageal obstruction, pyloric stenosis, squamous cell carcinoma of the esophagus, and vocal cord paralysis with consequent airway obstruction.

- A. True      B. False

### **Chlorine-Based Disinfectants Chloramines**

#### **Chloramine Disadvantages**

263. 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**

264. \_\_\_\_\_:  $\text{NH}_3 + \text{HOCl} \rightarrow \text{NH}_2\text{Cl} + \text{H}_2\text{O}$

- A. Free chlorine      C. Monochloramine  
B. Dichloramine      D. None of the above

265. \_\_\_\_\_:  $\text{NHCl}_2 + 3\text{HOCl} \rightarrow \text{NHCl}_3 + 3\text{H}_2\text{O}$

- A. Trichloramine      C. Ammonia and chlorine compounds  
B. Dichloramine      D. None of the above

266. Free chlorine reacts with the chloramine to produce hydrogen ion, water, and \_\_\_\_\_ which will come out of solution. In the case of the monochloramine, the following reaction occurs:  $2\text{NH}_2\text{Cl} + \text{HOCl} \rightarrow \text{N}_2 + 6\text{HCl} + \text{H}_2\text{O}$

- A. Nitrogen gas      C. Ammonia  
B. Hydrogen      D. None of the above

267. \_\_\_\_\_:  $\text{NH}_2\text{Cl} + 2\text{HOCl} \rightarrow \text{NHCl}_2 + 2\text{H}_2\text{O}$

- A. Trichloramine      C. Ammonia and chlorine compounds  
B. Dichloramine      D. None of the above

268. 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
- B. Dichloramine
- C. Monochloramine and dichloramine
- D. None of the above

### Post Chlorination

269. Post chlorination is normally 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

270. Drinking water requires a large addition of chlorine because there must be a residual amount of chlorine in the water that will carry through the system until it reaches the tap of the user. After Post chlorination, the water is retained in a clear well prior to distribution.

- A. True
- B. False

### Understanding Water Disinfection

#### Wastewater Disinfection

271. There are several chemicals and processes that will \_\_\_\_\_, but none are universally applicable as with chlorine.

- A. Limit the effects of organic material
- B. Limit the travel of pathogens
- C. Disinfect wastewater
- D. None of the above

#### Water Disinfection

272. Disinfection is usually the final stage in the water treatment process in order to limit the effects of organic material, suspended solids and \_\_\_\_\_.

- A. Organic material
- B. Other contaminants
- C. Residual level of disinfection
- D. None of the above

#### Chlorate Ion

273. Which of the following terms is predicted by VSEPR, about chlorate anions?

- A. Acid/base balance
- B. Stable perchlorates
- C. Trigonal pyramidal structures
- D. None of the above

274. \_\_\_\_\_ were once widely used in pyrotechnics, though their use has fallen due to their instability.

- A. Chlorates
- B. Perchlorates
- C. Chlorides
- D. None of the above

275. Chlorates are powerful reducers and should be kept away from organics or easily oxidized materials.

- A. True
- B. False

#### Chloride Ion

276. The chloride ion is formed when elemental chlorine, gains an electron to form an anion (negatively-charged ion) Cl<sup>-</sup>.

- A. True
- B. False

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

277. The salts of \_\_\_\_\_ contain chloride ions and can also be called chlorides.

- A. Hydrochloric acid C. Hypochlorous acid  
B.  $H_2SO_4$  D. None of the above

278. \_\_\_\_\_, more commonly called chloromethane, ( $CH_3Cl$ ) is an organic covalently bonded compound, which does not contain a chloride ion.

- A. Chlorate C. Methyl chloride  
B. Sodium chloride D. None of the above

279. Which of the following compounds is an example of table salt, which is sodium chloride with the chemical formula?

- A.  $CaCl_2$  C.  $ClO_2^-$   
B.  $NaCl$  D. None of the above

280. \_\_\_\_\_ is also the prosthetic group present in the amylase enzyme. Another example is calcium chloride with the chemical formula  $CaCl_2$ .

- A.  $CaCl_2$  C.  $ClO_4$   
B. A chloride ion D. None of the above

281. Which of the following compounds is used for maintaining unpaved roads and for sanite fortifying roadbases for new construction?

- A.  $CaCl_2$  C.  $ClO_2^-$   
B.  $ClO_4$  D. None of the above

282. Chlorine dioxide is a closely monitored constituent of the mud system

- A. True B. False

283. 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 C. Chlorine dioxide  
B. Chloride D. None of the above

### Chlorite Ion

284. The chlorite ion is?

- A.  $ClO_2^-$  C.  $ClO_3^-$ ,  
B.  $ClO_4$  D. None of the above

285. Chlorine can assume an additional oxidation state of +4 is seen in the neutral compound \_\_\_\_\_, which has a similar structure to chlorite  $ClO_2^-$  and the cation chloryl.

- A. Chlorine dioxide  $ClO_2$  C. Chlorite ion of  $ClO_2^-$   
B. Chloride D. None of the above

### Chlorine Dioxide

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

- A.  $CaCl_2$  C.  $ClO_2$   
B.  $ClO$  D. None of the above

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

### Haloacetic Acids

287. 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

288. The inductive effect caused by the \_\_\_\_\_ often result in the higher acidity of these compounds by stabilizing the negative charge of the conjugate base.

- A. Carboxylic acids
- C. Electronegative halogens
- B. Disinfection by-products
- D. None of the above

### Contaminants in Drinking Water

289. Which of the following terms expresses an exposure to such substances in drinking water has been associated with a number of health outcomes by epidemiological studies, although the putative agent in such studies has not been identified?

- A. Carboxylic acids
- C. Electronegative halogens
- B. Disinfection by-products
- D. None of the above

### Hypochlorites

290. Hypochlorites are calcium or sodium salts of hypochlorous acid and are supplied either dry or in liquid form (as, for instance, in commercial bleach). The same residuals are obtained as with gas chlorine, but the effect on the \_\_\_\_\_ of the treated water is different.

- A. Temperature
- C. Negative charge
- B. pH
- D. None of the above

291. Hypochlorite compounds contain an excess of \_\_\_\_\_ and tend to raise the pH of the water.

- A. Acid
- C. Hypochlorite compounds
- B. Alkali
- D. None of the above

292. \_\_\_\_\_ is the only liquid hypochlorite disinfectant in current use. There are several grades and proprietary forms available.

- A. High-test calcium hypochlorite(s)
- C. Sodium hypochlorite
- B. Calcium hypochlorite tablets
- D. None of the above

### Emergency Procedures

293. Emergency procedures in the case of a large uncontrolled chlorine leak: Notify local emergency response team, warn and evacuate people in adjacent areas, be sure that no one enters the leak area without adequate self-contained breathing equipment.

- A. True
- B. False

294. Safety precautions when using chlorine gas: In addition to protective clothing and goggles, chlorine gas should be used only in a well-ventilated area so that any leaking gas cannot concentrate.

- A. True
- B. False

295. Several symptoms of chlorine exposure: Burning of eyes, nose, and mouth, coughing, sneezing, choking, nausea and vomiting; headaches and dizziness; fatal pulmonary edema, pneumonia, and skin blisters.

- A. True
- B. False

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



296. When using chlorine gas: In addition to protective clothing and goggles, chlorine gas should be used only in a well-ventilated area so that any leaking gas cannot \_\_\_\_\_.

- A. Concentrate
- B. Conflagrate
- C. Combust
- D. None of the above

297. HOCl and OCl<sup>-</sup>: The OCl<sup>-</sup> is the hypochlorite ion and both of these species are known as free available chlorine, they are the two main chemical species formed by chlorine in water and they are known collectively as \_\_\_\_\_ and the \_\_\_\_\_.

- A. Hypochlorous acid, Cl<sub>2</sub>
- B. Hypochlorous acid, Hypochlorite ion
- C. Combined Available Chlorine, Total
- D. None of the above

298. Which of the following terms when added to water, rapidly hydrolyzes, the chemical equations best describe this reaction is  $Cl_2 + H_2O \rightarrow H^+ + Cl^- + HOCl$ ?

- A. Chlorine gas
- B. Monochloramine
- C. Combined Available Chlorine
- D. None of the above

299. Which of the following is the most germicidal of the chlorine compounds with the possible exception of chlorine dioxide?

- A. Hydrochlorous acid
- B. Hypochlorous acid
- C. Combined Available Chlorine
- D. None of the above

300. Monochloramine, Dichloramine, and trichloramine are known as \_\_\_\_\_.  $Cl_2 + NH_4$ .

- A. Hydrochlorous acid
- B. Hypochlorous acid
- C. Combined Available Chlorine
- D. None of the above

## Summary

### Disinfection Byproducts

301. Which term represents when disinfectants used in water treatment plants react with bromide and/or natural organic matter present in the source water?

- A. Disinfection byproducts
- B. Naturally occurring bromide
- C. Occurring organic and inorganic matter in water
- D. None of the above

302. Which term represents which regulations have been established have been identified in drinking water, including trihalomethanes, haloacetic acids, bromate, and chlorite?

- A. Chlorine dioxide
- B. HAA5
- C. Disinfection byproducts
- D. None of the above

### Trihalomethanes (THM)

303. Bromide represents a group of four chemicals that are formed along with other disinfection byproducts when chlorine used to control microbial contaminants in drinking water react with naturally occurring organic and inorganic matter in water.

- A. True
- B. False

304. Which term represents are chloroform, bromodichloromethane, dibromochloromethane, and bromoform?

- A. Chloroform
- B. HAA5
- C. Trihalomethanes
- D. None of the above

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

### Haloacetic Acids (HAA5)

305. Which term represents substances in drinking water react with naturally occurring organic and inorganic matter in water?

- A. Disinfection byproducts
- B. Microbial contaminants
- C. Occurring organic and inorganic matter in water
- D. None of the above

306. Which term represents monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid?

- A. Chlorine dioxide
- B. HAA5
- C. Chlorite
- D. None of the above

307. Bromate is a chemical that is formed when \_\_\_\_\_ is used to disinfect drinking water reacts with naturally occurring bromide found in source water.

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

308. Which term represents a byproduct formed when chlorine dioxide is used to disinfect water?

- A. Chlorine dioxide
- B. HAA5
- C. Chlorite
- D. None of the above

### Chloroform

309. 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

### Sodium Chlorate

310. Sodium Chlorate can also be synthesized by passing \_\_\_\_\_ into a hot sodium hydroxide solution. It is then purified by crystallization.

- A. Chlorate
- B. Oxygen
- C. Chlorine gas
- D. None of the above

### Chloramines

311. 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

312. Which term provides a durable residual, and are often used as a secondary disinfectant for long distribution lines and where free chlorine demand is high?

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

313. Bromate represents a compound that may be used instead of chlorine in order to reduce chlorinated byproduct formation and to remove some taste and odor problems.

- A. True
- B. False

### Chlorine Dioxide

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

- A. True
- B. False

315. In most generators, sodium chlorite and elemental chlorine are mixed in solution, which almost instantaneously forms chlorine dioxide.

- A. True      B. False

316. 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                      C. Carbon dioxide  
B. Sodium hypochlorite      D. None of the above

317. \_\_\_\_\_ 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          C. Carbon dioxide  
B. Sodium hypochlorite      D. None of the above

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

318. Which of the following terms is 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. CXT concept      C. CXT formula  
B. CXT values      D. None of the above

319. Which term demonstrates that if an operator chooses to decrease the chlorine concentration, the required contact time must be lengthened?

- A. CXT formula      C. Pound per day  
B. CXT values      D. None of the above

320. When free available chlorine residuals are desired, the characteristics of the water will determine how this will be accomplished. This may have to be considered:

If the water contains no ammonia or \_\_\_\_\_, any application of chlorine will yield a free residual once it has reacted with any bacteria, virus and other microorganisms present in the water.

- A. Other nitrogen compounds      C. Iron, manganese, organic matter  
B. Chloramines                      D. None of the above

321. If the water contains \_\_\_\_\_, it results in the formation of a combined residual, which must be destroyed by applying an excess of chlorine.

- A. Ammonia                      C. Iron, manganese, organic matter  
B. Chloramines                  D. None of the above

322. Breakpoint chlorination is the name of the process of adding chlorine to water until the chlorine demand has been satisfied.

- A. True      B. False

## **Waterborne Pathogens Section**

### **Protozoan Caused Diseases**

323. Which of the following bugs is larger than bacteria and viruses but still microscopic; they invade and inhabit the gastrointestinal tract?

- A. Hepatitis A                  C. Protozoan pathogens  
B. E.coli                          D. None of the above

324. Some of the parasites enter the environment in a dormant form, with a protective cell wall, called a?  
A. Lamblia    C. Cyst  
B. Shell       D. None of the above

**Giardia lamblia**

325. Which of the following bugs has been responsible for more community-wide outbreaks of disease in the U.S. than any other, and drug treatment are not 100% effective?  
A. Giardia lamblia       C. Giardiasis  
B. Cryptosporidiosis     D. None of the above

326. All of these diseases, with the exception of \_\_\_\_\_, have one symptom in common: diarrhea. They also have the same mode of transmission, fecal-oral, whether through person-to-person or animal-to-person contact.  
A. HIV infection       C. Hepatitis A  
B. Giardiasis         D. None of the above

**Primary Waterborne Diseases Section**

327. 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

328. 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

329. Campylobacter, the basics. It's a bacterium. It causes diarrheal illness.  
A. True         B. False

330. Campylobacter is primarily associated with poultry, animals, and humans.  
A. True         B. False

331. 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

332. 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

333. 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

334. Which of the following is typically associated with soil and water?  
A. Hepatitis A virus    C. Pseudomonas  
B. Legionella         D. None of the above

335. Hepatitis A virus is resistant to combined chlorines, so it is important to have an adequate free chlorine residual. Fecal matter can shield Hepatitis A virus from chlorine.

- A. True      B. False

336. Cryptosporidium is typically associated with animals and humans, and it can be acquired through consuming fecally contaminated food, contact with fecally contaminated soil and water.

- A. True      B. False

337. Cryptosporidium, prevention. Prevention strategies for this pathogen include source protection. A CT value of 50 is required when dealing with fecally accidents. CT equals a concentration, in parts per million, while time equals a contact time in minutes.

- A. True      B. False

338. 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

339. 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

340. 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

341. Humans are the reservoir for the Norovirus. Prevention strategies for this pathogen include?

- A. Internal protection      C. Containment protection  
B. Source protection      D. None of the above

### **Waterborne Bacterial Diseases**

342. Campylobacteriosis outbreaks have most often been associated with food, especially chicken and un-pasteurized milk, as well as un-chlorinated water. These organisms are also an important cause of "travelers' diarrhea." Medical treatment generally is not prescribed for campylobacteriosis because recovery is usually rapid.

- A. True      B. False

343. Cholera, Legionellosis, salmonellosis, shigellosis, yersiniosis, are other bacterial diseases that can be transmitted through water. All bacteria in water are readily killed or inactivated with chlorine or other disinfectants.

- A. True      B. False

344. Campylobacteriosis is the most common diarrheal illness caused by bacteria. Other symptoms include abdominal pain, malaise, fever, nausea and vomiting; and begin three to five days after exposure. The illness is frequently over within two to five days and usually lasts no more than 10 days.

- A. True      B. False

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

### **Dangerous Waterborne Microbes**

345. Which of the following is a parasite that enters lakes and rivers through sewage and animal waste. It causes cryptosporidiosis, a mild gastrointestinal disease. The disease can be severe or fatal for people with severely weakened immune systems.

- A. Coliform Bacteria
- C. Giardia lamblia
- B. Cryptosporidium
- D. None of the above

346. Which of the following are microscopic organisms that live in the intestines of warm-blooded animals? They also live in the waste material, or feces, excreted from the intestinal tract. When fecal coliform bacteria are present in high numbers in a water sample, it means that the water has received fecal matter from one source or another.

- A. Fecal coliform bacteria
- C. Shigella dysenteriae
- B. Cryptosporidium
- D. None of the above

347. Which of the following are common in the environment and are generally not harmful? However, the presence of these bacteria in drinking water are usually a result of a problem with the treatment system or the pipes which distribute water, and indicates that the water may be contaminated with germs that can cause disease.

- A. Coliform Bacteria
- C. Giardia lamblia
- B. Cryptosporidium
- D. None of the above

348. 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

### **Bacteriological Monitoring Introduction**

349. Which of the following are usually harmless, occur in high densities in their natural environment and are easily cultured in relatively simple bacteriological media?

- A. Indicator bacteria
- C. Viruses
- B. Amoebas
- D. None of the above

350. Indicators in common use today for routine monitoring of drinking water include total coliforms, fecal coliforms, and?

- A. Cryptosporidium
- C. Escherichia coli (E. coli)
- B. Protozoa
- D. None of the above

351. According to the text, the routine microbiological analysis of your water is for?

- A. Contamination
- C. Coliform bacteria
- B. Colloids
- D. None of the above

### **Bacteria Sampling**

352. Water samples for \_\_\_\_\_ must always be collected in a sterile container.

- A. Amoebas
- C. Viruses
- B. Bacteria tests
- D. None of the above

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

## Methods

353. 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
- B. Coliform
- C. Total coliform analysis
- D. None of the above

## Microbial Regulations

354. 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

355. Among Surface Water Treatment Rule provisions, the rule requires that a public water system, using surface water (or ground water under the direct influence of surface water) as its source, have sufficient treatment to reduce the source water concentration of protozoa and coliform bacteria by at least 99.9% and 99.99%, respectively.

- A. True
- B. False

356. The Surface Water Treatment Rule suggests treatment criteria to assure that these performance recommendations are met; they may include turbidity limits, disinfectant residual and disinfectant contact time conditions.

- A. True
- B. False

## Basic Types of Water Samples

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

- A. True
- B. False

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

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

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

359. 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
- B. Trigger: Level 2 Assessment
- C. All of the above
- D. None of the above

360. 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
- B. Special
- C. Routine
- D. None of the above

361. A PWS fails to take every required repeat sample after any single TC+ sample

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

362. A PWS incurs an E. coli MCL violation.

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

363. A PWS collecting at least 40 samples per month has greater than 5.0 percent of the routine/repeat samples in the same month that are TC+.

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

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

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

365. Noncommunity and nontransient noncommunity public water systems will sample at the same frequency as a like sized community public water system if:

1. It has more than 1,000 daily population and has ground water as a source, or
2. It serves 25 or more daily population and utilizes surface water as a source or ground water under the direct influence of surface water as its source.

- A. True
- B. False

366. Noncommunity and nontransient, noncommunity water systems with less than 10,000 daily population and groundwater as a source will sample on an annual basis.

- A. True
- B. False

#### **Positive or Coliform Present Results**

367. 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**

368. 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

#### **Total Coliforms**

369. This MCL is based on the presence of total coliforms, and compliance is on a daily or weekly basis, depending on your water system type and state rule.

- A. True
- B. False

370. For systems which 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:**

371. Which determines a violation of nitrate?

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



### Revised Total Coliform Rule (RTCR) Summary

372. 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

373. The RTCR requires public water systems that are vulnerable to microbial contamination to identify and fix problems.  
A. True      B. False

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

375. The RTCR suggests the frequency and timing of required microbial testing based on, public water type and source water type.  
A. True      B. False

376. The water provider shall collect repeat samples (at least 3) for each TC+ positive routine sample.  
A. True      B. False

377. The RTCR upholds the purpose of the 1989 TCR to protect public health by ensuring the duplicity of the drinking water distribution system and monitoring for the absence of microbial contamination.  
A. True      B. False

378. 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

379. The water provider shall develop and follow a sample-siting plan that designates the PWS's collection schedule. This includes location of \_\_\_\_\_.  
A. Routine and repeat water samples      C. Microbial contamination  
B. Reduced monitoring      D. Repeat water samples

380. 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      C. Microbial contamination  
B. Reduced monitoring      D. Repeat water samples

381. PN is required for violations incurred. Within required timeframes, the PWS must use the required health effects language and notify the public if they did not comply with certain requirements of the RTCR. The type of \_\_\_\_\_ depends on the severity of the violation.  
A. CCR(s)      C. MCL violation  
B. PN      D. TC+ routine or repeat sample

382. For PWSs on quarterly or annual routine sampling, collect additional routine samples (at least 3) in the month after a \_\_\_\_\_.  
A. CCR(s)      C. Total coliform positive samples  
B. PN      D. TC+ routine or repeat sample

383. 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

384. 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

385. 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

### Disinfection Key

386. The RTCR requires 99.99% or 4 log inactivation of \_\_\_\_\_.

- A. Enteric viruses
- B. Crypto
- C. Giardia lamblia cysts
- D. None of the above

387. The RTCR requires 99% or 2 log inactivation of \_\_\_\_\_.

- A. Enteric viruses
- B. Crypto
- C. Giardia lamblia cysts
- D. None of the above

388. The RTCR requires 99.9% or 3 log inactivation of \_\_\_\_\_.

- A. Enteric viruses
- B. Crypto
- C. Giardia lamblia cysts
- D. None of the above

389. The RTCR requires the chlorine residual leaving the plant must be = or \_\_\_\_\_ mg/L and measurable throughout the system.

- A. > 0.2
- B. 2.0
- C. 0.2
- D. None of the above

### Summary

#### Detailed Disinfection Supplement Section

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

390. 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

391. The CXT formula demonstrates that if an operator chooses to decrease the chlorine concentration, the required contact time must be lengthened.

- A. True
- B. False

392. As higher strength chlorine solutions are used, contact times may be reduced.

- A. True
- B. False



402. Chloramines are formed by reactions with?  
A. Acid and Cl<sub>2</sub>      C. Folic Acid and Cl<sub>2</sub>  
B. Ammonia and Cl<sub>2</sub>   D. None of the above

### Microbial Regulations

403. 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

404. 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

405. The EPA established a MCL of 0.0010 for all public water systems and a 99% removal requirement for Cryptosporidium in filtered public water systems that serve at least 100,000 people. The new rule will tighten turbidity standards by December 2001.  
A. True      B. False

### EPA's Drinking Water Regulations for Disinfectants

406. Chlorine is the most widely used water disinfectant due to its effectiveness and cost.  
A. True      B. False
407. Using chlorine as a drinking water disinfectant has prevented millions of water borne diseases, such as typhoid, cholera, dysentery, and diarrhea. Most states require community water systems to use chlorination.  
A. True      B. False
408. 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

409. Oxidation reactions are where chlorine \_\_\_\_\_ compounds present in water.  
A. Reduces      C. Oxidizes  
B. Forms      D. None of the above

410. \_\_\_\_\_ 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

411. 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
412. 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
413. Which of the following rules apply to all community and non-community water systems using a disinfectant such as chlorine, chloramines, ozone and chlorine dioxide?  
 A. TTHM and HAA5 Rule      C. A community water system (CWS)  
 B. Disinfectants and Disinfection Byproducts (DBP)    D. None of the above
414. The Long Term 2 Enhanced Surface Water Treatment Rule (LT2) rule applies to all water systems using \_\_\_\_\_ under the influence of a surface water, as well as groundwater/surface water blends.  
 A. Surface water, groundwater      C. DBP MCLs Rule  
 B. Disinfection byproducts (DBPs) Rule    D. None of the above
415. Which of the following rules began in 2006 with the characterization of raw water Cryptosporidium and E. coli levels?  
 A. DBPs requirements              C. Stage 1 Disinfectant and Disinfection Byproduct Rule  
 B. The LT2 requirements          D. None of the above
416. Which of the following rules applies to all public water systems using groundwater?  
 A. Groundwater Rule (GWR)      C. Long Term 2 Enhanced Surface Rule (LT2)  
 B. SDWA in 1996                  D. None of the above
417. 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**

418. 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
419. 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

420. 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)
- B. The Stage 2 DBP rule
- C. Long Term 2 Enhanced Surface Water Treatment Rule (LT2)
- D. None of the above

421. Which of the following rules focuses on public health protection by limiting exposure to DBPs, specifically total trihalomethanes and five haloacetic acids, which can form in water through disinfectants used to control microbial pathogens?

- A. Stage 1 DBPR
- B. The Stage 2 DBP rule
- C. Long Term 2 Enhanced Surface Water Treatment Rule
- D. None of the above

422. Which of the following rules has been highly effective in protecting public health and has also evolved to respond to new and emerging threats to safe drinking water?

- A. Stage 2 DBPR
- B. Safe Drinking Water Act (SDWA)
- C. Surface Water Treatment Rule
- D. None of the above

423. Which of the following terms is one of the major public health advances in the 20th century?

- A. Major public health advances
- B. Disinfection of drinking water
- C. Amendments to the SDWA in 1996
- D. None of the above

424. There are specific microbial pathogens, such as \_\_\_\_\_, which can cause illness, and are highly resistant to traditional disinfection practices.

- A. Enteric virus(es)
- B. Cryptosporidium
- C. C. perfringens
- D. None of the above

425. The Stage 1 Disinfectants and Disinfection Byproducts Rule and \_\_\_\_\_, promulgated in December 1998.

- A. The Stage 2 DBPR
- B. SDWA
- C. Interim Enhanced Surface Water Treatment Rule
- D. None of the above

426. Which of the following rules will reduce potential cancer and reproductive and developmental health risks from disinfection byproducts?

- A. DBP exposure
- B. Stage 2 Disinfection Byproducts Rule
- C. Traditional disinfection practices
- D. None of the above

427. Stage 2 Disinfection Byproducts Rule strengthens public health protection for customers by tightening \_\_\_\_\_ for two groups of DBPs, trihalomethanes and haloacetic acids.

- A. Primary or residual disinfectant
- B. Major public health advances
- C. Compliance monitoring requirements
- D. None of the above

## Are THMs and HAAs the only disinfection byproducts?

428. 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

429. 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:

430. 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

431. 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

432. 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

433. 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

434. It is extremely important that water treatment plants ensure that methods used to control chlorination by-products do not compromise the effectiveness of water disinfection.

- A. True
- B. False

435. 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

436. \_\_\_\_\_ 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

437. 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
- B. Chlorite, Chlorine
- C. Ozone, Ozone
- D. None of the above

438. 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
- B. Chlorite
- C. Chloramines
- D. None of the above

439. Chlorine dioxide can be an effective disinfectant, but it forms?

- A. Chlorate and Chlorite
- B. THMS
- C. Chloramines
- D. None of the above

## Water Chemistry Section

### pH Testing Section

440. When an atom loses \_\_\_\_\_ and thus has more protons than electrons, the atom is a positively-charged ion or cation.

- A. A proton
- B. Charge
- C. An electron
- D. None of the above

441. Pure water has a pH very close to?

- A. 7
- B. 7.5
- C. 7.7
- D. None of the above

442. \_\_\_\_\_ are determined using a concentration cell with transference, by measuring the potential difference between a hydrogen electrode and a standard electrode such as the silver chloride electrode.

- A. Primary pH standard values
- B. Alkalinity
- C. pH measurement(s)
- D. None of the above

443. Mathematically, pH is the negative logarithm of the activity of the (solvated) hydronium ion, more often expressed as the measure of the?

- A. Electron concentration
- B. Alkalinity concentration
- C. Hydronium ion concentration
- D. None of the above

444. Which of the following terms for aqueous solutions can be done with a glass electrode and a pH meter, or using indicators?

- A. Primary sampling
- B. Measurement of pH
- C. Determining values
- D. None of the above

445. The pH scale is logarithmic and therefore pH is?

- A. An universal indicator
- B. A dimensionless quantity
- C. An excess of alkaline earth metal concentrations
- D. None of the above

446. Measuring alkalinity is important in determining a stream's ability to neutralize acidic pollution from rainfall or wastewater. It is one of the best measures of the sensitivity of the stream to acid inputs. There can be long-term changes in the \_\_\_\_\_ of rivers and streams in response to human disturbances.

- A. Acid
- B. Alkalinity
- C. pH measurement(s)
- D. None of the above



447. pH is defined as the decimal logarithm of the reciprocal of the \_\_\_\_\_,  $a_{H^+}$ , in a solution.
- A. Hydrogen ion activity      C. Brønsted–Lowry acid–base theory  
 B. Acid-base behavior      D. None of the above
448. Which of the following terms may be used to measure pH, by making use of the fact that their color changes with pH?
- A. Indicators      C. A set of non-linear simultaneous equations  
 B. Spectrophotometer      D. None of the above
449. Alkalinity is the name given to the quantitative capacity of an aqueous solution to neutralize an?
- A. Acid      C. Bond formation  
 B. Base      D. None of the above
450. Which of the following terms of the color of a test solution with a standard color chart provides a means to measure pH accurate to the nearest whole number?
- A. Universal indicator      C. Visual comparison  
 B. Colorwheel measurement      D. None of the above
451. The pH scale is traceable to a set of standard solutions whose pH is established by US EPA.
- A. True      B. False
452. 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
453. 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
454. 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
455. The calculation of the pH of a solution containing acids and/or bases is an example of a chemical speciation calculation, that is, a mathematical procedure for calculating the concentrations of all chemical species that are present in the solution. The complexity of the procedure depends on the?
- A. Nature of the solution      C. Alkaline earth metal concentrations  
 B. pH      D. None of the above
456. Under normal circumstances this means that the concentration of hydrogen ions in acidic solution can be taken to be equal to the concentration of the acid. The pH is then equal to minus the logarithm of?
- A. The concentration value      C. A set of non-linear simultaneous equations  
 B. The pH      D. None of the above

457. Alkalinity of water is its acid-neutralizing capacity. It is the sum of all the titratable bases. The measured value may vary significantly with the?

- A. End-point pH
- B. Alkalinity
- C. pH measurement(s)
- D. None of the above

458. For strong acids and bases no calculations are necessary except in extreme situations. The pH of a solution containing a weak acid requires the solution of a quadratic equation. The pH of a solution containing a weak base may require the?

- A. Solution of a cubic equation
- B. Non-linear simultaneous equations
- C. Excess of alkaline earth metal concentrations
- D. None of the above

459. Alkalinity is a measure of this missing term and can be interpreted in terms of specific substances only when the chemical composition of the sample is known.

- A. Universal indicator
- B. An aggregate property of water
- C. Excess of alkaline earth metal concentrations
- D. None of the above

460. More precise measurements are possible if the color is measured spectrophotometrically, using a?

- A. Universal indicator
- B. Colorimeter or spectrophotometer
- C. Set of non-linear simultaneous equations
- D. None of the above

461. For strong acids and bases no calculations are necessary except in extreme situations. The pH of a solution containing a weak acid requires?

- A. The concentration value
- B. The solution of a quadratic equation
- C. Excess of alkaline concentrations
- D. None of the above

462. Alkalinity in excess of which term is significant in determining the suitability of water for irrigation?

- A. 8
- B. pH of 7
- C. Alkaline earth metal concentrations
- D. None of the above

463. The calculation of the pH of a solution containing acids and/or bases is an example of a \_\_\_\_\_ calculation, that is, a mathematical procedure for calculating the concentrations of all chemical species that are present in the solution

- A. Chemical speciation
- B. Spectrophotometer
- C. Visual comparison
- D. None of the above

464. Since pH is a logarithmic scale, a difference of one pH unit is equivalent to \_\_\_\_\_ difference in hydrogen ion concentration

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

### Alkalinity Sub-Section

465. Which of the following terms measurements is used in the interpretation and control of water and wastewater treatment processes?

- A. Acid
- B. Alkalinity
- C. Hydrogen bond formation
- D. None of the above

466. Which of the following terms are compounds that, for practical purposes, are completely dissociated in water.

- A. Strong acids and bases
- B. Chemical ions in chains
- C. Strong bases and weak acids
- D. None of the above

467. The pH of a solution containing a \_\_\_\_\_ may require the solution of a cubic equation.

- A. Strong acids and bases
- B. Strong base
- C. Weak base
- D. None of the above

468. Sodium hydroxide, NaOH, is an example of a?

- A. Weak base
- B. Strong base
- C. Strong acid
- D. None of the above

469. According to the text, what is the pH of pure water at 50 °C?

- A. 7.7
- B. 7.00
- C. 6.55
- D. None of the above

### Halogens- Halides

470. 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

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

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

472. 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

473. 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

474. 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

475. This halogen is needed only in very small amounts for the production of thyroid hormones such as thyroxine?

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

476. Neither fluorine nor bromine are believed to be really essential for humans, although small amounts of \_\_\_\_\_ can make tooth enamel resistant to decay.

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

## Halogens

477. All Halogens have 7 electrons in their outer shells, giving them an oxidation number of -1. The halogens exist, at room temperature, in all three states of matter:  
A. True      B. False

## Lab Analyst Section

478. Turbidity is measured to evaluate the performance of \_\_\_\_\_.  
A. Water treatment plant(s)    C. Colloidal to coarse dispersions  
B. An aesthetic point            D. None of the above

479. Turbidity is caused by wide variety of suspended matter that range in size from colloidal to coarse dispersions, depending upon the \_\_\_\_\_, and ranges from pure inorganic substances to those that are highly organic in nature.  
A. Water treatment plant(s)    C. Degree of turbulence  
B. An aesthetic point            D. None of the above

480. Turbid waters are undesirable from \_\_\_\_\_ of view in drinking water supplies.  
A. Water treatment plant(s)    C. Colloidal to coarse dispersions  
B. An aesthetic point            D. None of the above

## Surface Water (SW) System Compliance

481. Sample the \_\_\_\_\_ at the clear well  
A. Individual filter effluent    C. Combined filter turbidity  
B. 95% of samples              D. None of the above

482. 0.34 NTU in \_\_\_\_\_, never to exceed 1.0 NTU spike  
A. Individual filter effluent    C. Combined filter turbidity  
B. 95% of samples              D. None of the above

483. Sample turbidity at each \_\_\_\_\_  
A. Individual filter effluent    C. Combined filter turbidity  
B. 95% of samples              D. None of the above

## Turbidity Key

484. Turbidity is normally measured in mg/L and its size is measured in multimeters.  
A. True      B. False

485. Turbidity can be particles in the water consisting of finely divided solids, larger than bacteria, visible by the naked eye; ranging in size from 10 to 150mm.  
A. True      B. False

## Cloudy Water

486. In order to have gravity affect these particles, we must somehow make them larger, somehow have them come together (agglomerate); in other words, somehow make them "stick" together, thereby increasing their size and mass.  
A. True      B. False

### Method 1623 - Cryptosporidium and Giardia Analysis

487. Special sterilization procedures are needed for equipment used in the collection of samples for?

- A. Total Organisms
- B. Cryptosporidium and Giardia
- C. Indicator bugs
- D. None of the above

488. Washing the equipment free of residual sodium hypochlorite solution with three rinses of filter-sterilized water; do not de-chlorinate the equipment using?

- A. Sodium thiosulfate
- B. Sulfuric acid
- C. Sodium hypochlorite solution
- D. None of the above

489. According to the text, composite the sample in a 10-L cubitainer that is pre-sterilized by the manufacturer. The cubitainer is sent in a cardboard box to laboratory for \_\_\_\_\_ analysis.

- A. Cryptosporidium
- B. Indicator organisms
- C. Cholera, polio, typhoid, hepatitis
- D. None of the above

### Cryptosporidium and Giardia Analysis

490. For Cryptosporidium and Giardia analysis by Method 1623 (U.S. Environmental Protection Agency, 1999c), collect 10 L of streamwater for each protozoan pathogen using standard sampling techniques described in Myers and Sylvester (1997). Special sterilization procedures are needed for equipment used in the collection of samples for Cholera, polio, typhoid, hepatitis. Autoclaving is not effective in neutralizing the epitopes on the surfaces of the oocysts and cysts that will react with the antibodies used for detection.

- A. True
- B. False

491. Submerge the equipment in a vessel containing 12 percent hypochlorite solution for 30 minutes. Wash the equipment free of residual sodium thiosulfate solution with three rinses of filter-sterilized water; do not de-chlorinate the equipment using Dibromochloromethane.

- A. True
- B. False

492. Composite the sample in a 10-L cubitainer that is pre-sterilized by the manufacturer. The cubitainer is sent in a cardboard box to laboratory for Cholera, polio, typhoid, hepatitis analysis. The sample does not have to be kept on ice during transport.

- A. True
- B. False

### Laboratory Analysis

#### Sample Procedures

493. Samples need to be kept on ice and shipped to a central laboratory for analysis of coliphage, C. perfringens, Cryptosporidium, Giardia, and enteric viruses by the current analytical methods. The single-agar layer (SAL), direct plating method with induction of streptomycin and ampicillin is recommended for detection of somatic and F-specific coliphage in streamwater samples.

- A. True
- B. False

494. Viral plaques are easily identified and enumerated by the distinct blue circle. Because of contamination by naturally occurring bacteria in streamwater samples, antibiotic-resistant host-culture strains, E. coli CN-13 (resistant to nalidixic acid) and E. Coli F-amp (resistant to streptomycin and ampicillin) are used as hosts for somatic and F-specific coliphage, respectively.

- A. True
- B. False

495. After incubation, the plates are exposed to ammonium hydroxide, and all straw-colored colonies that turn dark pink to magenta are counted as \_\_\_\_\_.

- A. Enteric virus(es)
- B. E. coli host culture)
- C. C. perfringens
- D. None of the above

496. Which type of analyses is done with 100-, 30-, and 10-mL volumes of streamwater? In the case of a high-flow or high-turbidity streamwater sample, lower sample volumes may be plated.

- A. Coliphages
- B. C. perfringens
- C. Large sample volumes
- D. None of the above

497. Fluorescently labeled antibodies and vital dye were used to make the final microscopic identification of?

- A. Enteric virus(es)
- B. Oocyst(s)
- C. Oocysts and cysts
- D. None of the above

### **QA/QC Activities and Measures**

498. QA/QC activities and measures to take to reduce contamination. Use a sterilization indicator, such as autoclave tape, in preparing Viral plaques and other equipment for collection of microbiological samples to determine whether adequate temperatures and pressures have been attained during autoclaving.

- A. True
- B. False

### **Field personnel should do the following:**

499. Which are the same as equipment blanks except that they are generated under actual field conditions?

- A. Reagent water quality
- B. Microbiological sampling
- C. Field blanks
- D. None of the above

### **Quality Assurance and Quality Control in the Laboratory**

500. According to the text, microbiology laboratories must follow good laboratory practices—cleanliness, safety practices, procedures for \_\_\_\_\_, specifications for reagent water quality—as set forth by American Public Health Association.

- A. Reagent water quality
- B. Microbiological sampling
- C. Media preparation
- D. None of the above