

Registration Form

**Arsenic CEU Training Course \$200.00**

1<sup>st</sup> Edition

**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*

**Address** \_\_\_\_\_

**City** \_\_\_\_\_ **State** \_\_\_\_\_ **Zip** \_\_\_\_\_

**Email** \_\_\_\_\_ **Fax (\_\_\_\_)** \_\_\_\_\_

**Phone:**  
**Home (\_\_\_\_)** \_\_\_\_\_ **Work (\_\_\_\_)** \_\_\_\_\_

**Operator ID #** \_\_\_\_\_ **Exp. Date** \_\_\_\_\_

**Class/Grade** \_\_\_\_\_

*Your certificate will be mailed to you in about two weeks.*

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

Pretreatment \_\_\_ Collection \_\_\_ Wastewater Treatment \_\_\_

Other \_\_\_\_\_

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

**If you've paid on the Internet, please write your Customer#** \_\_\_\_\_

**Please invoice me, my PO#** \_\_\_\_\_

**Please pay with your credit card on our website under Bookstore or Buy Now. Or call us and provide your credit card information.**

## **DISCLAIMER NOTICE**

I understand that it is my responsibility to ensure that this CEU course is either approved or accepted in my State for CEU credit. I understand State laws and rules change on a frequent basis and I believe this course is currently accepted in my State for CEU or contact hour credit, if it is not, I will not hold Technical Learning College responsible. I fully understand that this type of study program deals with dangerous, changing conditions and various laws and that I will not hold Technical Learning College, Technical Learning Consultants, Inc. (TLC) liable in any fashion for any errors, omissions, advice, suggestions or neglect contained in this CEU education training course or for any violation or injury, death, neglect, damage or loss of your license or certification caused in any fashion by this CEU education training or course material suggestion or error or my lack of submitting paperwork. It is my responsibility to call or contact TLC if I need help or assistance and double-check to ensure my registration page and assignment has been received and graded. It is my responsibility to ensure all information is correct and to abide with all rules and regulations.

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

*You can obtain a printed version of the course manual from TLC for an additional \$69.95 plus shipping charges.*

## **AFFIDAVIT OF EXAM COMPLETION**

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

## **Grading Information**

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

For security purposes, please fax or e-mail a copy of your driver's license and always call us to confirm we've received your assignment and to confirm your identity.

**Do not solely depend on TLC's Approval list for it may be outdated.**

**A second certificate of completion for a second State Agency \$50 processing fee.**

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

**We require the final exam to be proctored.**

<http://www.abctlc.com/downloads/PDF/PROCTORFORM.pdf>

***We will stop mailing the certificate of completion so we need either your fax number or e-mail address. We will e-mail the certificate to you, if no e-mail address; we will fax it to you.***

# Arsenic Answer Key 1<sup>st</sup> Edition

Name \_\_\_\_\_

Phone \_\_\_\_\_

***You are solely responsible in ensuring that this course is accepted for credit by your State. No refunds. Did you check with your State agency to ensure this course is accepted for credit?***

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

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

**Do not solely depend on TLC's Approval list for it may be outdated.**

**What is the approval number if Applicable? \_\_\_\_\_**

***You are responsible to ensure that TLC receives the Assignment and Registration Key. Please call us to ensure that we received it.***

***You can use Adobe Acrobat DC Program to complete the assignment.***

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

- |                 |                 |                 |
|-----------------|-----------------|-----------------|
| 1. A B C D E F  | 15. A B C D E F | 29. A B C D E F |
| 2. A B C D E F  | 16. A B C D E F | 30. A B C D E F |
| 3. A B C D E F  | 17. A B C D E F | 31. A B C D E F |
| 4. A B C D E F  | 18. A B C D E F | 32. A B C D E F |
| 5. A B C D E F  | 19. A B C D E F | 33. A B C D E F |
| 6. A B C D E F  | 20. A B C D E F | 34. A B C D E F |
| 7. A B C D E F  | 21. A B C D E F | 35. A B C D E F |
| 8. A B C D E F  | 22. A B C D E F | 36. A B C D E F |
| 9. A B C D E F  | 23. A B C D E F | 37. A B C D E F |
| 10. A B C D E F | 24. A B C D E F | 38. A B C D E F |
| 11. A B C D E F | 25. A B C D E F | 39. A B C D E F |
| 12. A B C D E F | 26. A B C D E F | 40. A B C D E F |
| 13. A B C D E F | 27. A B C D E F | 41. A B C D E F |
| 14. A B C D E F | 28. A B C D E F | 42. A B C D E F |

43. A B C D E F  
44. A B C D E F  
45. A B C D E F  
46. A B C D E F  
47. A B C D E F  
48. A B C D E F  
49. A B C D E F  
50. A B C D E F  
51. A B C D E F  
52. A B C D E F  
53. A B C D E F  
54. A B C D E F  
55. A B C D E F  
56. A B C D E F  
57. A B C D E F  
58. A B C D E F  
59. A B C D E F  
60. A B C D E F  
61. A B C D E F  
62. A B C D E F  
63. A B C D E F  
64. A B C D E F  
65. A B C D E F  
66. A B C D E F  
67. A B C D E F  
68. A B C D E F  
69. A B C D E F  
70. A B C D E F  
71. A B C D E F  
72. A B C D E F  
73. A B C D E F  
74. A B C D E F  
75. A B C D E F  
76. A B C D E F  
77. A B C D E F  
78. A B C D E F  
79. A B C D E F  
80. A B C D E F  
81. A B C D E F  
82. A B C D E F  
83. A B C D E F  
84. A B C D E F  
85. A B C D E F  
86. A B C D E F  
87. A B C D E F  
88. A B C D E F  
89. A B C D E F  
90. A B C D E F  
91. A B C D E F  
92. A B C D E F  
93. A B C D E F  
94. A B C D E F  
95. A B C D E F  
96. A B C D E F  
97. A B C D E F  
98. A B C D E F  
99. A B C D E F  
100. A B C D E F  
101. A B C D E F  
102. A B C D E F  
103. A B C D E F  
104. A B C D E F  
105. A B C D E F  
106. A B C D E F  
107. A B C D E F  
108. A B C D E F  
109. A B C D E F  
110. A B C D E F  
111. A B C D E F  
112. A B C D E F  
113. A B C D E F  
114. A B C D E F  
115. A B C D E F  
116. A B C D E F  
117. A B C D E F  
118. A B C D E F  
119. A B C D E F  
120. A B C D E F  
121. A B C D E F  
122. A B C D E F  
123. A B C D E F  
124. A B C D E F  
125. A B C D E F  
126. A B C D E F  
127. A B C D E F  
128. A B C D E F  
129. A B C D E F  
130. A B C D E F  
131. A B C D E F  
132. A B C D E F  
133. A B C D E F  
134. A B C D E F  
135. A B C D E F  
136. A B C D E F  
137. A B C D E F  
138. A B C D E F

139. A B C D E F  
140. A B C D E F  
141. A B C D E F  
142. A B C D E F  
143. A B C D E F  
144. A B C D E F  
145. A B C D E F  
146. A B C D E F  
147. A B C D E F  
148. A B C D E F  
149. A B C D E F  
150. A B C D E F  
151. A B C D E F  
152. A B C D E F  
153. A B C D E F  
154. A B C D E F  
155. A B C D E F  
156. A B C D E F  
157. A B C D E F  
158. A B C D E F  
159. A B C D E F  
160. A B C D E F  
161. A B C D E F  
162. A B C D E F  
163. A B C D E F  
164. A B C D E F  
165. A B C D E F  
166. A B C D E F  
167. A B C D E F  
168. A B C D E F  
169. A B C D E F  
170. A B C D E F  
171. A B C D E F  
172. A B C D E F  
173. A B C D E F  
174. A B C D E F  
175. A B C D E F  
176. A B C D E F  
177. A B C D E F  
178. A B C D E F  
179. A B C D E F  
180. A B C D E F  
181. A B C D E F  
182. A B C D E F  
183. A B C D E F  
184. A B C D E F  
185. A B C D E F  
186. A B C D E F  
187. A B C D E F  
188. A B C D E F  
189. A B C D E F  
190. A B C D E F  
191. A B C D E F  
192. A B C D E F  
193. A B C D E F  
194. A B C D E F  
195. A B C D E F  
196. A B C D E F  
197. A B C D E F  
198. A B C D E F  
199. A B C D E F  
200. A B C D E F  
201. A B C D E F  
202. A B C D E F  
203. A B C D E F  
204. A B C D E F  
205. A B C D E F  
206. A B C D E F  
207. A B C D E F  
208. A B C D E F  
209. A B C D E F  
210. A B C D E F  
211. A B C D E F  
212. A B C D E F  
213. A B C D E F  
214. A B C D E F  
215. A B C D E F  
216. A B C D E F  
217. A B C D E F  
218. A B C D E F  
219. A B C D E F  
220. A B C D E F  
221. A B C D E F  
222. A B C D E F  
223. A B C D E F  
224. A B C D E F  
225. A B C D E F  
226. A B C D E F  
227. A B C D E F  
228. A B C D E F  
229. A B C D E F  
230. A B C D E F  
231. A B C D E F  
232. A B C D E F  
233. A B C D E F  
234. A B C D E F

235. A B C D E F

236. A B C D E F

237. A B C D E F

238. A B C D E F

239. A B C D E F

240. A B C D E F

241. A B C D E F

242. A B C D E F

243. A B C D E F

244. A B C D E F

245. A B C D E F

246. A B C D E F

247. A B C D E F

248. A B C D E F

249. A B C D E F

250. A B C D E F

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

*Please mail this with your final exam*

# ARSENIC CEU TRAINING COURSE

## CUSTOMER SERVICE RESPONSE CARD

DATE: \_\_\_\_\_

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

ADDRESS: \_\_\_\_\_

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

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

1. Please rate the difficulty of your course.  
Very Easy   0   1   2   3   4   5   Very Difficult
2. Please rate the difficulty of the testing process.  
Very Easy   0   1   2   3   4   5   Very Difficult
3. Please rate the subject matter on the exam to your actual field or work.  
Very Similar   0   1   2   3   4   5   Very Different
4. How did you hear about this Course? \_\_\_\_\_

What would you do to improve the course?

---

---

Any other concerns or comments.

---

---





## Arsenic CEU Training Course Assignment 1<sup>st</sup> Edition

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

You'll 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. We prefer if this exam is proctored. No intentional trick questions. 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. You can e-mail or fax your Answer Key along with the Registration Form to TLC. **(S) Means answer may be plural or singular**

### **Pick the Best Answer**

1. This term means a public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents.
  - A. Community water system
  - B. Noncommunity water system
  - C. Public water system
  - D. Maximum contaminant level
  - E. None of the Above
  
2. This term means a system for the provision to the public of water for human consumption through pipes.
  - A. Community water system
  - B. Noncommunity water system
  - C. Public water system
  - D. Maximum contaminant level
  - E. None of the Above
  
3. A public water system is either a "community water system" or a "\_\_\_\_\_."
  - A. Community water system
  - B. Noncommunity water system
  - C. Public water system
  - D. Maximum contaminant level
  - E. None of the Above
  
4. This term means the agency of the State or Tribal government which has jurisdiction over public water systems.
  - A. Community water system
  - B. Noncommunity water system
  - C. Public water system
  - D. Maximum contaminant level
  - E. None of the Above

5. This term means all water which is open to the atmosphere and subject to surface runoff.
- Community water system
  - Noncommunity water system
  - Public water system
  - Maximum contaminant level
  - None of the Above
6. This term means the maximum permissible level of a contaminant in water which is delivered to any user of a public water system.
- Community water system
  - Noncommunity water system
  - Maximum contaminant level goal
  - Maximum contaminant level
  - None of the Above
7. This term means the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety.
- Community water system
  - Noncommunity water system
  - Maximum contaminant level goal
  - Maximum contaminant level
  - None of the Above
8. Non-transient non-community water system or NTNCWS means a public water system that is not a \_\_\_\_\_ and that regularly serves at least 25 of the same persons over 6 months per year.
- Contaminant
  - Compliance cycle
  - Point-of-entry treatment device
  - Compliance period
  - None of the Above
9. This term means a treatment device applied to the drinking water entering a house or building for the purpose of reducing contaminants in the drinking water distributed throughout the house or building.
- Contaminant
  - Compliance cycle
  - Point-of-entry treatment device
  - Compliance period
  - None of the Above
10. This term means the nine-year calendar year cycle during which public water systems must monitor.
- Contaminant
  - Compliance cycle
  - Point-of-entry treatment device
  - Compliance period
  - None of the Above
11. This term means a three-year calendar year period within a compliance cycle.
- Contaminant
  - Compliance cycle
  - Point-of-entry treatment device
  - Compliance period
  - None of the Above

12. This term means any physical, chemical, biological, or radiological substance or matter in water.
- A. Contaminant
  - B. Compliance cycle
  - C. Point-of-entry treatment device
  - D. Compliance period
13. This term means a treatment device applied to a single tap used for the purpose of reducing contaminants in drinking water at that one tap.
- A. Contaminant
  - B. Compliance cycle
  - C. Point-of-entry treatment device
  - D. Compliance period
  - E. None of the Above
14. This term means the best technology, treatment techniques, or other means which the Administrator finds, after examination for efficacy under field conditions and not solely under laboratory conditions, are available (taking cost into consideration).
- A. Contaminant
  - B. Compliance cycle
  - C. Point-of-entry treatment device
  - D. Compliance period
  - E. None of the Above
15. The EPA affirms the appropriateness of a \_\_\_\_\_ (or regulatory level) of 10 parts per billion (ppb) for arsenic in drinking water.
- A. Community water system
  - B. Noncommunity water system
  - C. Maximum contaminant level goal
  - D. Maximum contaminant level
  - E. None of the Above
16. The \_\_\_\_\_ will provide additional protection to at least 13 million Americans from cancer and other health problems.
- A. Community water system
  - B. Noncommunity water system
  - C. Maximum contaminant level goal
  - D. Maximum contaminant level
  - E. None of the Above

**Reducing arsenic from 50 ppb to 10ppb will prevent:**

17. More than 19-31 cases of skin cancer per year, prevent 5-8 deaths each year from this cancer.
- A. True
  - B. False
18. More than 19-25 cases of lung cancer, prevent 16-22 deaths from this cancer,
- A. True
  - B. False
19. A number of cases of non-cancerous diseases, such as liver disease.
- A. True
  - B. False

20. Of the 74,000 systems regulated by this MCL, approximately 50,000 systems will have to install treatment or take other steps to comply with the 10 ppb standard.
- A. True
  - B. False
21. The EPA estimates that the average annual household water bill may increase by \$32 per year, however, for households in systems that serve less than 3,300 people the cost will be substantially higher (ranging from \$58 - \$327 per household).
- A. True
  - B. False
22. Water systems must meet this **10 ppb** standard by January 23, 2009.
- A. True
  - B. False
23. Noncommunity water systems are required to publish annual reports with information on water source, treatment, and any detected contaminants by June 1 of each year. Under the arsenic rule, systems that detect arsenic between 10 and 50 ppb must include health effects information in the CCR. Systems that detect arsenic between 5 and 10 ppb must include an educational statement in the CCR.
- A. True
  - B. False
24. Systems with arsenic concentrations above 5 ppb (in violation of the existing standard) continue to be required to state they are in violation and must provide health effects information.
- A. True
  - B. False
25. Both community water systems (**CWSs**) and non-transient, non-community water systems (**NTNCWSs**) will be required to reduce the arsenic concentration in their drinking water systems to 1 ppm.
- A. True
  - B. False
26. A PWS is a public water system that serves at least 25 locations or 50 residents regularly year round (e.g., most cities and towns, apartments, and mobile home parks with their own water supplies).
- A. True
  - B. False
27. An CWS is a public water system that is not a NTNCWS and serves at least 25 of the same people more than 12 months of the year (e.g., schools, churches, nursing homes, and factories).
- A. True
  - B. False
28. This final rule is also a vehicle for clarifying two compliance requirements for inorganic contaminants (**IOCs**), volatile organic contaminants (**VOCs**), and synthetic organic contaminants (**SOCs**). When a system fails to collect the required number of samples, compliance averages will be based on the actual number of samples collected. Also, new public water systems and systems using new sources of water must demonstrate compliance within State-specified time and sampling frequencies.
- A. True
  - B. False

29. All CWSs and all NTNCWSs that exceed the MCL of 10 µg/L will be required to come into compliance 5 years after the promulgation of the final rule. Beginning with reports that are due by July 1, 2002, all CWSs will begin providing health information and arsenic concentrations in their annual consumer confidence report (**CCR**) for water that exceeds ½ the revised MCL.
- A. True  
B. False
30. In the 1996 amendments to the Clean Water Act (**CWA**), Congress directed the EPA to propose a new arsenic regulation by January 1, 2000 and to issue the final rule by January 1, 2001 (Congress subsequently extended the final rule date to June 22, 2001). The EPA published the proposed rule for arsenic on June 22, 2000. The rule proposed an MCL of 5 µg/L for arsenic and the EPA took comment on regulatory options of 3 µg/L (the feasible level), 10 µg/L and 50 µg/L.
- A. True  
B. False
31. The 1996 amendments to SDWA added discretionary authority for the EPA Administrator to adjust the maximum contaminant level (**MCL**) if the benefits would not justify the costs (1412(b)(6)).
- A. True  
B. False
32. After careful consideration of the benefits and the costs, the EPA has decided to set the drinking water standard for arsenic higher than the technically feasible level of 10 µg/L because EPA believes that the costs would justify the benefits at this level.
- A. True  
B. False
33. In most drinking water sources, the organic form of arsenic tends to be more predominant than inorganic forms. Organic arsenic in drinking water can exert toxic effects after acute (short-term) or chronic (long-term) exposure.
- A. True  
B. False
34. Chronic exposures to high doses of organic arsenic can cause adverse effects, such exposures do not occur from public water systems in the U.S. that are in compliance with the existing MCL of 50 µg/L.
- A. True  
B. False

**These health effects include:**

35. **Cancerous Effects:** skin, bladder, lung, kidney, nasal passages, liver and prostate cancer;
- A. True  
B. False
36. **Non-cancerous effects:** cardiovascular, pulmonary, immunological, neurological and endocrine (e.g., diabetes) effects.
- A. True  
B. False
37. The contamination of a drinking water source by arsenic cannot result from either natural or human activities.
- A. True  
B. False

38. Arsenic is an element that occurs naturally in rocks and soil, water, air, plants, and animals.  
A. True  
B. False
39. Volcanic activity, the erosion of rocks and minerals, and forest fires are natural sources that can release arsenic into the environment.  
A. True  
B. False
40. Although about 90 percent of the arsenic used by industry in the United States is currently used for medical purposes, arsenic is also used in paints, drugs, dyes, soaps, metals and semi-conductors.  
A. True  
B. False
41. Agricultural applications, mining, and smelting do not contribute to arsenic releases.  
A. True  
B. False
42. Higher levels of arsenic tend to be found more in surface water sources than in ground water sources (i.e., lakes and rivers) of drinking water.  
A. True  
B. False
43. Compared to the rest of the United States, the Eastern states have more systems with arsenic levels greater than 10 µg/L.  
A. True  
B. False
44. Parts of the Midwest and New England have some systems whose current arsenic levels are greater than 10 µg/L, but more systems with arsenic levels that range from 2-10 µg/L of arsenic.  
A. True  
B. False
45. While many systems may not have detected arsenic in their drinking water above 10 µg/L, there may be geographic "**hot spots**" with systems that may have higher levels of arsenic than the predicted occurrence for that area.  
A. True  
B. False
46. About 3,000 (or 5.5 percent) of the nation's 54,000 CWSs and 1,100 (or 5.5 percent) of the 20,000 NTNCWSs will need to take measures to lower arsenic in their drinking water. Of the affected systems, 97 percent serve less than 10,000 people.  
A. True  
B. False
47. Exclusions can help ensure that systems which are able to comply with the revised arsenic MCL will have the opportunity to gain the resources or take the steps needed to comply with the rule in an appropriate period of time.  
A. True  
B. False

48. The use of exemptions will also allow systems time to develop a plan for long-term capacity. States can act before the revised arsenic MCL goes into effect and move water systems more expeditiously toward compliance.
- A. True
  - B. False
49. All public water systems (**PWSs**) that meet the minimum criteria outlined in the SDWA are eligible for an exemption of up to three years. For larger water systems, exemptions can provide up to five additional years beyond the compliance date of the MCL to achieve compliance.
- A. True
  - B. False
50. Without exemptions, water systems might not begin to move toward compliance until 2006. Exemptions encourage water systems to start down the path to compliance now, so that public health is better protected.
- A. True
  - B. False
51. The use of exemptions can help ensure that systems which are unable to comply with the arsenic MCL by January 23, 2006 will have the opportunity to gain the resources needed to comply with the rule in an appropriate period of time.
- A. True
  - B. False
52. Congress explicitly created the exemption provisions to address the needs of systems facing difficult, "**compelling**" circumstances that preclude their being able to achieve compliance in the normal time frame. Exemptions can help systems from ever being in non-compliance.
- A. True
  - B. False
53. The most frequently used technology for soil and waste containing arsenic is Ion Exchange.
- A. True
  - B. False
54. Vitrification may be used when a combination of contaminants are present that cannot be effectively treated using solidification/stabilization. It has also been used when the vitrification residual could be sold as a commercial product.
- A. True
  - B. False
55. Soil washing/acid extraction typically requires large amounts of energy, can be more expensive than S/S, and may generate off-gasses containing arsenic.
- A. True
  - B. False
56. Vitrification extraction is used to treat soil primarily. However, it is not applicable to all types of soil or to waste.
- A. True
  - B. False

57. Precipitation/coprecipitation treatment has been used primarily to recycle arsenic from industrial wastes containing high concentrations of arsenic from metals refining and smelting operations.
- A. True
  - B. False
58. For water containing arsenic, the most frequently used technology is Pyrometallurgical treatment.
- A. True
  - B. False
59. Precipitation/coprecipitation is frequently used to treat arsenic contaminated water, and is capable of treating a wide range of influent concentrations to the revised MCL for arsenic.
- A. True
  - B. False
60. Systems using this technology generally require skilled operators; therefore, precipitation/coprecipitation is more cost effective at a large scale where labor costs can be spread over a larger amount of treated water produced.
- A. True
  - B. False
61. The effectiveness of adsorption and ion exchange for arsenic treatment is more likely than precipitation/coprecipitation to be affected by characteristics and contaminants other than arsenic.
- A. True
  - B. False
62. Oxidation/Reduction uses chemicals to transform dissolved contaminants into an insoluble solid. In coprecipitation, the target contaminant may be dissolved or in a colloidal or suspended form.
- A. True
  - B. False
63. Dissolved contaminants do not precipitate, but are adsorbed onto another species that is precipitated.
- A. True
  - B. False
64. Polymer Reagent become enmeshed with other precipitated species, or are removed through processes such as coagulation and flocculation.
- A. True
  - B. False
65. Precipitation/coprecipitation does not involves pH adjustment and addition of a chemical precipitant or coagulant; it does not include addition of a chemical oxidant.
- A. True
  - B. False
66. Oxidation of arsenic to its less soluble As(V) state can increase the effectiveness of precipitation/coprecipitation processes, and can be done as a separate pretreatment step or as part of the precipitation process.
- A. True
  - B. False



67. Some pretreatment processes that oxidize As(III) to As(V) include ozonation, photo oxidation, or the addition of oxidizing chemicals such as potassium permanganate, sodium hypochlorite, or hydrogen peroxide.
- A. True
  - B. False
68. Oxidation is commonly used to remove the solid precipitate.
- A. True
  - B. False
69. Precipitation/coprecipitation is frequently used to treat water contaminated with organics.
- A. True
  - B. False
70. The chemistry of precipitation/coprecipitation is often complex, and depends upon a variety of factors, including the speciation of arsenic, the chemical precipitants used and their concentrations, the pH of the water, and the presence of other chemicals in the water to be treated.
- A. True
  - B. False
71. The presence of the more soluble trivalent state of arsenic may reduce the removal efficiency. The solubility of arsenic depends upon its valence state, pH, the specific arsenic compound, and the presence of other chemicals with which arsenic might react. Oxidation to As(V) could improve arsenic removal through precipitation/coprecipitation.
- A. True
  - B. False
72. In general, arsenic removal will be maximized at the pH at which the precipitated species is least soluble. The optimal pH range for precipitation/coprecipitation depends upon the waste treated and the specific treatment process.
- A. True
  - B. False
73. The presence of organics may impact the effectiveness of precipitation/coprecipitation. For example, sulfate could decrease arsenic removal in processes using ferric chloride as a coagulant, while the presence of calcium or iron may increase the removal of arsenic in these processes.
- A. True
  - B. False
74. Membrane filtration can remove a wide range of contaminants from water.
- A. True
  - B. False
75. Membrane filtration cannot reduce arsenic concentrations to less than 0.050 mg/L and in some cases has reduced arsenic concentrations to below 0.10 mg/L.
- A. True
  - B. False
76. Membrane filtration is sensitive to a variety of untreated water contaminants and characteristics. It also produces a larger volume of residuals and tends to be more expensive than other arsenic treatment technologies.
- A. True
  - B. False

77. Membrane filtration is used less frequently than precipitation/coprecipitation, adsorption, and ion exchange. It is most commonly used to treat groundwater and drinking water, or as a polishing step for precipitation processes.
- A. True
  - B. False
78. Membrane filtration separates contaminants from water by passing it through a semi-permeable barrier or membrane. The membrane allows some constituents to pass through, while blocking others.
- A. True
  - B. False
79. There are four types of membrane processes: microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO).
- A. True
  - B. False
80. All four of these processes are hydraulic-driven and are categorized by the size of the particles that can pass through the membranes or by the weight of water cut off (i.e., pore size) of the membrane.
- A. True
  - B. False
81. The force required to drive fluid across the membrane depends on the pore size; NF and RO require a relatively high pressure (50 to 150 pounds per square inch [psi]), while MF and UF require lower pressure (5 to 100 psi).
- A. True
  - B. False
82. The high pressure processes primarily remove contaminants through physical sieving, and the low pressure processes through chemical diffusion across the permeable membrane.
- A. True
  - B. False
83. Because arsenic species dissolved in water tend to have relatively low molecular weights, only NF and RO membrane processes are likely to effectively treat dissolved arsenic.
- A. True
  - B. False
84. MF has not been used with precipitation/coprecipitation to remove solids containing arsenic.
- A. True
  - B. False
85. MF generates two treatment residuals from the influent waste stream: a treated effluent (permeate) and a rejected waste stream of concentrated contaminants (reject).
- A. True
  - B. False
86. RO is a chemical process that primarily removes smaller ions typically associated with total dissolved solids.
- A. True
  - B. False

87. The molecular weight cut off for RO membranes ranges from 1 to 20,000, which is a significantly lower cut off than for NF membranes.
- A. True
  - B. False
88. The molecular weight cut off for NF membranes ranges from approximately 150 to 20,000. NF is a high-pressure process that primarily removes larger divalent ions associated with hardness (for example, calcium [Ca], and magnesium [Mg] but not monovalent salts (for example, sodium [Na] and chlorine [Cl]).
- A. True
  - B. False
89. RO is slightly less efficient than NF in removing dissolved arsenic from water.
- A. True
  - B. False
90. Suspended solids, high molecular weight, dissolved solids, organic compounds, and colloids - The presence of these constituents in the feed stream will not cause membrane fouling.
- A. True
  - B. False
91. Oxidation state of arsenic - Prior oxidation of the influent stream to convert As(III) to As(V) will decrease arsenic removal; As(V) is generally larger and is captured by the membrane more effectively than As(III).
- A. True
  - B. False
92. pH will not affect the adsorption of arsenic on the membrane by creating an electrostatic charge on the membrane surface.
- A. True
  - B. False
93. Low influent stream temperatures decrease membrane flux. Increasing system pressure or increasing the membrane surface area may compensate for low influent stream temperature.
- A. True
  - B. False
94. MF is a low-pressure process that primarily removes particles with a molecular weight above 50,000 or a particle size greater than 0.050 micrometers.
- A. True
  - B. False
95. The pore size of MF membranes is too large to effectively remove dissolved arsenic species, but MF can remove particulates containing arsenic and solids produced by precipitation/coprecipitation.
- A. True
  - B. False
96. Drinking water, surface water, groundwater, and industrial wastewater can be treated with membrane filtration technology.
- A. True
  - B. False
97. Membrane filtration can treat dissolved salts and other dissolved materials.
- A. True
  - B. False

98. Membrane technologies are capable of removing a wide range of dissolved contaminants and suspended solids from water. RO and NF technologies require additional chemical addition to ensure adequate separation. This type of treatment may only run in batch mode.
- A. True
  - B. False
99. Membrane filtration effectiveness is not sensitive to a variety of contaminants and characteristics in the untreated water. Suspended solids, organics, colloids, and other contaminants cannot cause membrane fouling.
- A. True
  - B. False
100. Membrane filtration is typically applied to groundwater and drinking water, which are less likely to contain fouling contaminants. It is also applied to remove solids from precipitation processes and as a polishing step for other water treatment technologies when lower concentrations must be achieved.
- A. True
  - B. False
101. Adsorption Treatment has been used to treat groundwater and drinking water containing arsenic.
- A. True
  - B. False
102. Adsorption Treatment typically can reduce arsenic concentrations to less than 0.050 mg/L and in some cases has reduced arsenic concentrations to below 0.010 mg/L.
- A. True
  - B. False
103. Adsorption Treatment is not sensitive to a variety of untreated water contaminants and characteristics.
- A. True
  - B. False
104. Adsorption Treatment is used more frequently than precipitation/coprecipitation, and is most commonly used to treat groundwater and drinking water, or as a polishing step for other water treatment processes.
- A. True
  - B. False
105. In adsorption treatment, solutes (contaminants) concentrate at the surface of a sorbent, thereby reducing their concentration in the bulk liquid phase.
- A. True
  - B. False
106. The adsorption media is usually packed into a column. As contaminated water is passed through the column, contaminants are adsorbed. When adsorption sites become filled, the column must be regenerated or disposed of and replaced with new media.
- A. True
  - B. False
107. Greensand is made from glauconite, a green, iron-rich, clay-like mineral that usually occurs as small pellets mixed with cement.
- A. True
  - B. False

108. As water passes through a greensand filtration bed, the  $\text{KMnO}_4$  oxidizes As(III) to As(V), and As(V) adsorbs onto the greensand surface.
- A. True
  - B. False
109. Arsenic is removed by ion exchange, displacing species from the manganese oxide (presumably hydroxide ion  $[\text{OH}^-]$  and water  $[\text{H}_2\text{O}]$ ).
- A. True
  - B. False
110. Adsorption Treatment when the  $\text{KMnO}_4$  is exhausted, the greensand media does not need to be regenerated or replaced.
- A. True
  - B. False
111. Greensand media is regenerated with a solution of excess  $\text{HNO}_3$ . Greensand filtration is also known as oxidation/filtration.
- A. True
  - B. False
112. Activated Carbon (AC) is the sorbent most commonly used to remove arsenic from drinking water, and has also been used for groundwater.
- A. True
  - B. False
113. The reported adsorption capacity of Activated Carbon ranges from 0.003 to 0.112 grams of arsenic per gram of AC. It is available in different mesh sizes and its particle size affects contaminant removal efficiency.
- A. True
  - B. False
114. Adsorption Treatment the regeneration process desorbs the arsenic. The regeneration fluid most commonly used for Activated Carbon treatment systems is a solution of sodium hydroxide.
- A. True
  - B. False
115. The most commonly used neutralization fluid is a solution of  $\text{CaHO}_4$ .
- A. True
  - B. False
116. The regeneration and neutralization steps for AA adsorption systems might produce a sludge because the alumina can be dissolved by the strong acids and bases used in these processes, forming an aluminum hydroxide precipitate in the spent regeneration and neutralization fluids.
- A. True
  - B. False
117. Activated Alumina (**AA**) is an organic sorbent that is commonly used to remove organic and metal contaminants from drinking water, groundwater, and wastewater.
- A. True
  - B. False

118. AA media are normally regenerated using thermal techniques to desorb and volatilize contaminants. However, regeneration of AA media used for the removal of arsenic from water might not be feasible.
- A. True
  - B. False
119. The arsenic might not volatilize at the temperatures typically used in AC regeneration. In addition, off-gas containing arsenic from the regeneration process may be difficult or expensive to manage.
- A. True
  - B. False
120. The reported adsorption capacity of AC is 0.020 grams of As(V) per gram of AC. As(III) is not effectively removed by AC. AC impregnated with metals such as copper and ferrous iron has a higher reported adsorption capacity for arsenic.
- A. True
  - B. False
121. Activated Carbon adsorption media include granular ferric hydroxide, ferric hydroxide-coated newspaper pulp, ferric oxide, iron oxide-coated sand, sulfur-modified iron, and iron filings mixed with sand.
- A. True
  - B. False
122. Mixed media has been used primarily to remove arsenic from drinking water. Processes that use these media typically remove alumina using ion exchange in combination with oxidation, precipitation/coprecipitation, acid treatment or filtration.
- A. True
  - B. False
123. Iron oxide-coated sand uses adsorption and ion exchange with surface hydroxides to selectively remove arsenic from water.
- A. True
  - B. False
124. The regeneration process is similar to that used for AA, and consists of rinsing the media with a regenerating solution containing excess sodium hydroxide, flushing with water, and neutralizing with a strong acid, such as sulfuric acid.
- A. True
  - B. False
125. Adsorption is frequently used to remove organic contaminants and metals from industrial wastewater. It has been used to remove arsenic from groundwater and drinking water.
- A. True
  - B. False
126. Adsorption treatment effectiveness can be evaluated by comparing influent and effluent contaminant concentrations.
- A. True
  - B. False

### **Factors Affecting Adsorption Performance**

127. Fouling - The presence of suspended solids, organics, solids, silica, or mica, can cause fouling of adsorption media.
- A. True
  - B. False

128. Arsenic oxidation state - Adsorption is more effective in removing As (III) than As (V).  
A. True  
B. False
129. Flow rate - Increasing the rate of flow through the adsorption unit can decrease the adsorption of contaminants.  
A. True  
B. False
130. Wastewater pH - The optimal pH to maximize adsorption of arsenic by activated alumina is basic (pH 11).  
A. True  
B. False
131. Adsorption Treatment for AA adsorption media, the spent regenerating solution might contain a high concentration of arsenic and other sorbed contaminants, and can be corrosive.  
A. True  
B. False
132. Spent AA is produced when the AA can no longer be regenerated. The spent AA will not require treatment prior to disposal.  
A. True  
B. False
133. Because regeneration of AA requires the use of strong acids and bases, some of the AA media becomes dissolved during the regeneration process. This can reduce the adsorptive capacity of the AA and cause the AA packing to become "**cemented**."  
A. True  
B. False
134. Regeneration of AC media involves the use of chemical energy, which does not release volatile arsenic compounds. Use of air pollution control equipment is not necessary to remove arsenic from the off-gas produced.  
A. True  
B. False
135. Competition for adsorption sites could reduce the effectiveness of adsorption because other constituents may be preferentially adsorbed, resulting in a need for more frequent bed regeneration or replacement. The presence of sulfate, chloride, and organic compounds have reportedly reduced the adsorption capacity of AA for arsenic.  
A. True  
B. False
136. Adsorption Treatment technology's effectiveness is also sensitive to a variety of contaminants and characteristics in the untreated water, and suspended solids, organics, silica, or mica can cause fouling.  
A. True  
B. False
137. Adsorption Treatment is typically applied to groundwater and drinking water, which are less likely to contain fouling contaminants. It may also be used as a polishing step for other water treatment technologies.  
A. True  
B. False

138. Contaminant concentration - Very high concentrations of competing contaminants may require frequent replacement or regeneration of adsorbent. The capacity of the adsorption media increases with increasing contaminant concentration.
- A. True
  - B. False
139. Low arsenic concentrations can quickly exhaust the adsorption media quickly, resulting in the need for frequent regeneration or replacement.
- A. True
  - B. False
140. Spent media - Spent media that can no longer be regenerated might require treatment or disposal.
- A. True
  - B. False
141. Ion exchange has been used to treat groundwater and drinking water containing arsenic.
- A. True
  - B. False
142. Ion exchange can reduce arsenic concentrations to less than 0.050 mg/L and in some cases has reduced arsenic concentrations to below 0.010 mg/L.
- A. True
  - B. False
143. Ion exchange effectiveness is sensitive to a variety of untreated water contaminants and characteristics. It is used less frequently than precipitation/coprecipitation, and is most commonly used to treat groundwater and drinking water, or as a polishing step for other water treatment processes.
- A. True
  - B. False
144. Ion exchange is a physical/chemical process in which ions held electrostatically on the surface of a solid are exchanged for ions of similar charge in a solution.
- A. True
  - B. False
145. It removes ions from the aqueous phase by the exchange of cations or anions between the contaminants and the exchange medium.
- A. True
  - B. False
146. The medium used for ion exchange is typically a resin made from synthetic organic materials, inorganic materials, or natural polymeric materials that contain ionic functional groups to which exchangeable ions are attached.
- A. True
  - B. False
147. Strong and weak acid resins exchange cations while strong and weak base resins exchange anions.
- A. True
  - B. False



148. Dissolved arsenic is usually in an anionic form, weak base resins tend to be effective over a smaller pH range, and strong base resins are typically used for arsenic treatment.
- A. True
  - B. False
149. Resins may also be categorized by the ion that is exchanged with the one in solution. For example, resins that exchange a chloride ion are referred to as chloride-form resins.
- A. True
  - B. False
150. Another way of categorizing resins is by the type of ion in solution that the resin preferentially exchanges. For example, resins that preferentially exchange sulfate ions are referred to as sulfate-selective. Both sulfate-selective and nitrate-selective resins have been used for arsenic removal.
- A. True
  - B. False
151. The resin is usually packed into a column, and as contaminated water is passed through the column, contaminant ions are exchanged for other ions such as chloride or hydroxide in the resin.
- A. True
  - B. False
152. Ion exchange is often preceded by treatments such as filtration and oil-water separation to remove organics, suspended solids, and other contaminants that can foul the resins and reduce their effectiveness.
- A. True
  - B. False
153. Ion exchange resins must be periodically regenerated to remove the adsorbed contaminants and replenish the exchanged ions.
- A. True
  - B. False
154. **Regeneration of a resin occurs in three steps:** Backwashing, Regeneration with a solution of ions, and Final rinsing to remove the regenerating solution.
- A. True
  - B. False
155. The regeneration process results in a backwash solution, a waste regenerating solution, and a waste rinse water. The volume of spent regeneration solution ranges from 1.5 to 10 percent of the treated water volume depending on the feed water quality and type of ion exchange unit.
- A. True
  - B. False
156. Ion exchange's regenerating solution may be used up to 25 times before treatment or disposal is required.
- A. True
  - B. False

#### **Factors Affecting Ion Exchange Performance**

157. Valence state - As(III) is generally not removed by ion exchange.
- A. True
  - B. False

158. Presence of competing ions - Competition for the exchange ion can reduce the effectiveness of ion exchange if ions in the resin are replaced by ions other than arsenic, resulting in a need for more frequent bed regeneration.
- A. True
  - B. False
159. Fouling - The presence of organics, suspended solids, calcium, or iron, can cause fouling of ion exchange resins.
- A. True
  - B. False
160. Presence of trivalent iron - The presence of Fe (III) could cause arsenic to form complexes with the iron that are not removed by ion exchange.
- A. True
  - B. False
161. pH - For chloride-form, strong-base resins, a pH in the range of 6.5 to 9 is optimal. Outside of this range, arsenic removal effectiveness decreases quickly.
- A. True
  - B. False
162. Ion exchange can be operated using multiple beds in series to reduce the need for bed regeneration; beds first in the series will require acid treatment first, and fresh beds can be added at the end of the chlorination process series.
- A. True
  - B. False
163. A single bed can also allow for continuous operation because some of the resin can be regenerated while others continue to treat water. Ion exchange beds are typically operated as a fixed bed, in which the water to be treated is passed over a mobile ion exchange resin.
- A. True
  - B. False
164. One variation on this approach is to operate the bed in a nonfixed, countercurrent fashion in which water is applied in one direction, usually downward, while spent ion exchange resin is removed from the top of the bed.
- A. True
  - B. False
165. Regenerated resin is added to the top of the bed. This method may reduce the frequency of resin regeneration.
- A. True
  - B. False
166. Cation exchange resins are used to remove soluble forms of arsenic from wastewater, groundwater, and drinking water. Ion exchange treatment is generally applicable to soil and waste.
- A. True
  - B. False
167. Ion exchange is not commonly used in drinking water treatment for softening, removal of calcium, magnesium, and other cations in exchange for sodium, and is not good for removing nitrate, arsenate, chromate, and selenate.
- A. True
  - B. False

168. Ion exchange of arsenic and groundwater, surface water, and drinking water is commercially available.
- A. True
  - B. False

**Factors Affecting Ion Exchange Costs**

169. Bed regeneration - Regenerating ion exchange beds reduces the amount of waste for disposal and the cost of operation.
- A. True
  - B. False
170. Sulfate - Sulfate (SO<sub>4</sub>) can compete with arsenic for ion exchange sites, thus reducing the exchange capacity of the ion exchange media for arsenic. This can result in a need for more frequent media regeneration or replacement, and associated higher costs.
- A. True
  - B. False
171. Permeable reactive barriers (**PRBs**) are being used to treat arsenic in groundwater at full scale at several sites. Although many candidate materials for the reactive portion of the barrier have been tested at bench scale, only zero valent iron and limestone have been used at full scale.
- A. True
  - B. False
172. The installation techniques for PRBs are established for depths more than 30 feet, and require innovative installation techniques for shallower installations.
- A. True
  - B. False
173. PRBs are applicable to the treatment of only organic and not for inorganic contaminants.
- A. True
  - B. False
174. The most frequent applications of PRBs is the in situ treatment of groundwater contaminated with chlorinated solvents.
- A. True
  - B. False
175. The cost of the reactive media will impact the overall cost of PRB remedies.
- A. True
  - B. False
176. Permeable reactive barriers (**PRBs**) are walls containing reactive media that are installed across the path of a contaminated groundwater plume to intercept the plume.
- A. True
  - B. False
177. Basic oxygen furnace slag allows water to pass through while the media remove the contaminants by precipitation, degradation, adsorption, or ion exchange.
- A. True
  - B. False
178. Ion exchange resin systems are built in two basic configurations: the funnel-and-gate and the continuous wall.
- A. True
  - B. False

179. The Surfactant modified zeolite system uses impermeable walls, for example, sheet piling or slurry walls, as a **"funnel"** to direct the contaminant plume to a **"gate(s)"** containing the reactive media, while the continuous wall transects the flow path of the plume with reactive media.
- A. True  
B. False
180. Most PRBs installed to date have had depths of 50 feet (ft) or more.
- A. True  
B. False
181. Those having depths of 30 ft or less can be installed with a continuous trencher, while depths between 30 and 70 ft require a more innovative installation method, such as biopolymers. Installation of PRBs at depths greater than 70 ft is more challenging.
- A. True  
B. False
182. PRB technology can treat both organic and inorganic contaminants.
- A. True  
B. False
183. Inorganic contaminants are broken down into more toxic elements and compounds, such as carbon dioxide and water.
- A. True  
B. False
184. Inorganic contaminants are converted to species that are less toxic or less mobile.
- A. True  
B. False
185. Inorganic contaminants that can be treated by PRBs include, but are not limited to, chromium (Cr), nickel (Ni), lead (Pb), uranium (U), technetium (Tc), iron (Fe), manganese (Mn), selenium (Se), cobalt (Co), copper (Cu), cadmium (Cd), zinc (Zn), arsenic (As), nitrate (NO<sub>3</sub><sup>-</sup>), sulfate (SO<sub>4</sub><sup>2-</sup>), and phosphate (PO<sub>4</sub><sup>3-</sup>).
- A. True  
B. False
186. The presence of fractured rock in contact with the PRB may allow groundwater to flow around, rather than through, the PRB.
- A. True  
B. False
187. PRBs may be difficult to install for deep aquifers and contaminant plumes (>70 ft deep).
- A. True  
B. False
188. The hydraulic conductivity of the barrier must be greater than that of the aquifer to prevent preferential flow around the barrier .
- A. True  
B. False
189. Site stratigraphy may affect PRB installation. For example, Ferric oxides and oxyhydroxides might be **"smeared"** during installation, reducing hydraulic conductivity near the PRB.
- A. True  
B. False

190. Permeability and reactivity of the barrier may be reduced by Surfactant-modified zeolite and microbial growth.  
A. True  
B. False
191. PRBs are a passive treatment technology, designed to function for a long time with little or no Activated alumina input.  
A. True  
B. False
192. PRBs produce less waste than active remediation (for example, extraction systems like pump and treat), as the contaminants are immobilized or altered in the subsurface.  
A. True  
B. False
193. PRBs can treat groundwater with Peat, humate, lignite, coal and can be effective over a range of concentrations. PRBs require no aboveground equipment, except monitoring devices, allowing return of the property to economic use during remediation.  
A. True  
B. False
194. PRBs are best applied to shallow, unconfined aquifer systems in Bauxite deposits, as long as the reactive material is more conductive than the aquifer.  
A. True  
B. False
195. PRBs rely on the natural movement of groundwater; therefore, aquifers with low hydraulic conductivity can require relatively long periods of time to be remediated.  
A. True  
B. False
196. PRBs do not remediate the entire plume, but only the portion of the plume that has passed through the PRB.  
A. True  
B. False
- Factors Affecting PRB Costs**
197. PRBs at depths greater than 30 feet may be more expensive to install, requiring special excavation equipment and construction materials.  
A. True  
B. False
198. Reactive media vary in cost, therefore the reactive media selected can affect PRB cost.  
A. True  
B. False
199. Electrokinetic treatment is an emerging remediation technology designed to remove heavy metal contaminants from soil and groundwater. The technology is most applicable to soil with small particle sizes, such as clay.  
A. True  
B. False
200. Electrokinetic treatment effectiveness may be limited by a variety of contaminants and soil and water characteristics.  
A. True  
B. False

201. Electrokinetic remediation is based on the theory that a low-density current will mobilize contaminants in the form of charged species. A current passed between electrodes is intended to cause water, ions, and particulates to move through the soil, waste, and water.
- A. True
  - B. False
202. With electrokinetic treatment contaminants arriving at the electrodes can be removed by means of electroplating or electrodeposition, precipitation or coprecipitation, adsorption, complexing with ion exchange resins, or by pumping of water (or other fluid) near the electrode.
- A. True
  - B. False
203. In situ coprecipitation treatment of arsenic uses the natural conductivity of the soil (created by pore water and dissolved salts) to affect movement of water, ions, and particulates through the soil.
- A. True
  - B. False
204. Water and/or chemical solutions can also be added to enhance the recovery of metals by electrokinetics.
- A. True
  - B. False
205. The applicability of electrokinetics to soil and water containing arsenic depends on the solubility of Oxalic Acid.
- A. True
  - B. False
206. Electrokinetic treatment is applicable to caustic-soluble polar compounds, but not to soluble metals.
- A. True
  - B. False
207. Salinity and cation exchange capacity – The technology is most efficient when these parameters are low. Chemical reduction of chloride ions at the anode by the electrokinetic process may also produce hydrogen gas.
- A. True
  - B. False
208. Soil moisture - Electrokinetic treatment requires adequate soil moisture; therefore addition of a conducting pore fluid may be required. Phosphoric Acid treatment is most applicable to saturated soils.
- A. True
  - B. False
209. Industrial wastes magnitude of the ionic charge - These factors affect the direction and rate of contaminant movement.
- A. True
  - B. False
210. Soil type - Electrokinetic treatment is most applicable to homogenous soils.
- A. True
  - B. False

211. Fine-grained soils are more amenable to electrokinetic treatment due to their small surface area, which provides numerous sites for reactions necessary for electrokinetic processes.
- A. True
  - B. False
212. pH - The pH will not affect process electrochemistry and cause precipitation of contaminants or other species, pH will not affect reducing soil permeability and inhibiting recovery.
- A. True
  - B. False
213. The deposition of precipitation solids may be prevented by flushing the anode with water or a dilute caustic.
- A. True
  - B. False
214. Electrokinetic treatment technology can also be applied ex situ to groundwater by passing the water between electrodes. The current causes arsenic to migrate toward the electrodes, and also alters the pH and oxidation-reduction potential of the water, causing arsenic to precipitate/coprecipitate. The solids are then removed from the water using clarification and filtration.
- A. True
  - B. False
215. Electrokinetic treatment is an in situ treatment process that has had limited use to treat soil, groundwater, and industrial wastes containing arsenic. It has also been used to treat other heavy metals such as zinc, cadmium, mercury, chromium, and copper.
- A. True
  - B. False
216. Electrokinetic treatment may be capable of removing contaminants from both saturated and unsaturated soil zones, and may be able to perform without the addition of chemical or biological agents to the site.
- A. True
  - B. False
217. Electrokinetic treatment technology also may be applicable to high-permeability soils, such as clay.
- A. True
  - B. False
218. Electrokinetics is an emerging technology with relatively few applications for arsenic treatment. It is an in situ treatment technology, and therefore does not require excavation of contaminated soil or pumping of contaminated groundwater. Its effectiveness may be limited by a variety of soil and contaminant characteristics.
- A. True
  - B. False
219. Charged metal or metalloid cations, such as As (V) and As (III) migrate to the negatively-charged electrode (cathode), while metal or metalloid anions migrate to the positively charged electrode (anode).
- A. True
  - B. False

220. Extraction may occur at the electrodes or in an external fluid cycling/extraction system.  
A. True  
B. False
221. Alternately, the metals can be stabilized in situ by injecting stabilizing agents that react with and immobilize the contaminants. Arsenic has been removed from soils treated by electrokinetics using an external fluid cycling/ extraction system.  
A. True  
B. False
222. Phytoremediation is designed to use ion exchange technology to degrade, extract, contain, or immobilize contaminants in soil, sediment, or groundwater.  
A. True  
B. False
223. Phytoremediation will utilize grasses with shallow roots are applied to groundwater and other plants are used for shallow soil contamination.  
A. True  
B. False

#### **Technology Description and Principles**

224. Phytoremediation is an emerging technology generally applicable only to shallow contamination that can be reached by plant roots.  
A. True  
B. False
225. Phytoremediation applies to all biological, chemical, and physical processes that are influenced by plants and the rhizosphere, and that aid in cleanup of the contaminated substances.  
A. True  
B. False
226. Phytoremediation may be applied in situ or ex situ, to soils, sludges, sediments, other solids, or groundwater.  
A. True  
B. False
227. The mechanisms of phytoremediation include phytoextraction (also known as phytoaccumulation, the uptake of contaminants by plant roots and the translocation/accumulation of contaminants into plant shoots and leaves), enhanced rhizosphere biodegradation (takes place in soil or groundwater immediately surrounding plant roots), phytodegradation (metabolism of contaminants within plant tissues), and phytostabilization (production of chemical compounds by plants to immobilize contaminants at the interface of roots and soil).  
A. True  
B. False
228. The data sources used for this course identified phytoremediation applications for arsenic using phytoextraction and phytostabilization.  
A. True  
B. False



229. The selection of the phytoremediating species depends upon the species ability to treat the contaminants and the depth of contamination. Plants with shallow roots (for example, grasses, corn) are appropriate only for contamination near the surface, typically in shallow soil.
- A. True
  - B. False
230. Plants with deeper roots, (for example, trees) may be capable of remediating deeper contaminants in soil or groundwater plumes.
- A. True
  - B. False
231. Examples of vegetation used in phytoremediation include sunflower, Indian mustard, corn, and grasses (such as ryegrass and prairie grasses).
- A. True
  - B. False
232. Some plant species, known as hyperaccumulators, absorb and concentrate contaminants within the plant at levels greater than the concentration in the surrounding soil or groundwater. The ratio of contaminant concentration in the plant to that in the surrounding soil or groundwater is known as the bioconcentration factor.
- A. True
  - B. False
233. A hyperaccumulating fern (*Pteris vittata*) has been used in the remediation of arsenic-contaminated soil, waste, and water. The fern can tolerate as much as 1,500 parts per million (ppm) of arsenic in soil, and can have a bioconcentration factor up to 265. The arsenic concentration in the plant can be as high as 2 percent (dry weight).
- A. True
  - B. False
234. The treatment depth is not limited to the depth of the plant root system.
- A. True
  - B. False
235. Sites with low to medium level contamination within the root zone are the best candidates for phytoremediation processes. High contaminant concentrations may be toxic to the remediating flora.
- A. True
  - B. False
236. Climatic conditions will not interfere or inhibit plant growth, slow remediation efforts, or decrease the length of the treatment period.
- A. True
  - B. False
237. In phytoaccumulation processes, contaminants are removed from the aqueous or dissolved phase. Phytoaccumulation is generally effective on contaminants that are insoluble or strongly bound to soil particles.
- A. True
  - B. False

238. Factors that affect plant growth and health, such as the presence of weeds and pests, and availability sufficient water and nutrients will affect phytoremediation processes.
- A. True
  - B. False
239. Phytoremediation has been applied to contaminants from soil, surface water, groundwater, leachate, and municipal and industrial wastewater.
- A. True
  - B. False
240. In addition to arsenic, examples of pollutants it can potentially address include petroleum hydrocarbons such as benzene, toluene, ethylbenzene, and xylenes (BTEX), polycyclic aromatic hydrocarbons (PAHs), pentachlorophenol, polychlorinated biphenyls (PCBs), chlorinated aliphatics (trichloroethylene, tetrachloroethylene, and 1,1,2,2-tetrachloroethane), ammunition wastes (2,4,6- trinitrotoluene or TNT, and RDX), metals (lead, cadmium, zinc, arsenic, chromium, selenium), pesticide wastes and runoff (atrazine, cyanazine, alachlor), radionuclides (cesium-137, strontium-90, and uranium), and nutrient wastes (ammonia, phosphate, and nitrate).
- A. True
  - B. False
241. Phytoremediation is conducted in situ and therefore does require extensive soil excavation. In addition, revegetation for the purpose of phytoremediation also can destroy parts of an ecosystem.
- A. True
  - B. False
242. This technology is best applied at sites with deep contamination. If phytostabilization is used, the vegetation and soil may require short-term maintenance to prevent release of the contaminants.
- A. True
  - B. False
243. Plant uptake and translocation of metals to the aboveground portions of the plant may introduce them into the food chain if the plants are consumed. Products could bioaccumulate in animals that ingest the plants.
- A. True
  - B. False
244. Biological treatment designed to remove arsenic from soil, waste, and water is an emerging remediation technology. The information sources used for this report identified a limited number of projects treating arsenic biologically. Sulfate-reducing bacteria was reduced to below 0.050 mg/L in one pilot-scale application.
- A. True
  - B. False
245. This technology promotes precipitation/coprecipitation of arsenic in water or leaching of arsenic in soil and waste. The leachate from bioleaching requires additional treatment for Arsenic-reducing bacteria prior to disposal.
- A. True
  - B. False

246. Biological treatment of arsenic is based on the theory that microorganisms that act directly on arsenic species or create ambient conditions that cause arsenic to precipitate/coprecipitate from water and leach from soil and waste.
- A. True
  - B. False
247. pH levels can inhibit microbial growth. For example, sulfate-reducing bacteria perform optimally in a pH range of 8.0 to 11.0.
- A. True
  - B. False
248. High arsenic concentrations may be toxic to microorganisms used in biological treatment.
- A. True
  - B. False
249. An adequate nutrient supply should be available to the microbes to enhance and stimulate growth. If the initial solution is nutrient deficient, nutrient addition may be necessary.
- A. True
  - B. False
250. High temperatures decrease biodegradation rates. Cooling may be required to maintain biological activity.
- A. True
  - B. False