CHAPTER 7 WATER POLLUTION
QUESTIONS AND PROBLEMS

1. Which of the following statements is true regarding chromium in water: (a) chromium(III) is suspected of being carcinogenic, (b) chromium(III) is less likely to be found in a soluble form than chromium(VI), (c) the toxicity of chromium(III) in electroplating wastewaters is decreased by oxidation to chromium(VI), (d) chromium is not an essential trace element, (e) chromium is known to form methylated species analogous to methylmercury compounds.
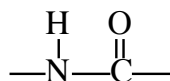
   Answer: (b)

2. What do mercury and arsenic have in common in regard to their interactions with bacteria in sediments?

   Answer: They are both converted to methylated forms by anoxic bacteria

3. What are some characteristics of radionuclides that make them especially hazardous to humans?

   Answer: They produce ionizing radiation and may be in elemental forms found in the body (radioactive iodine that accumulates in the thyroid) or elements that substitute for those in the body (radioactive strontium that substitutes for bone calcium).

4. To what class do pesticides containing the following group belong?

$$\begin{array}{cc} H & O \\ | & \| \\ -N-C- \end{array}$$

   Answer: Carbamates

5. Consider the following compound:
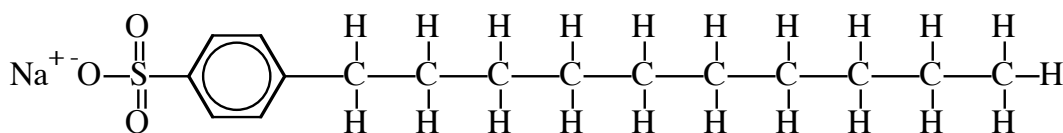
   Which of the following characteristics is not possessed by the compound: (a) one end of the molecule is hydrophilic and the other end in hydrophobic, (b) surface-active qualities, (c) the ability to lower surface tension of water, (d) good biodegradability, (e) tendency to cause foaming in sewage treatment plants.

   Answer: (e)

6. A certain pesticide is fatal to fish fingerlings at a level of 0.50 parts per million in water. A leaking metal can containing 5.00 kg of the pesticide was dumped into a stream with a flow of 10.0 liters per second moving at 1 kilometer per hour. The container leaks pesticide at a constant rate of 5 mg/sec. For what distance (in km) downstream is the water contaminated by fatal levels of the pesticide by the time the container is empty?

   Answer: The pesticide concentration in the contaminated water is 0.50 ppm = 0.50 mg/L. At a leakage rate of 5 mg/sec, the time taken to empty the container is $(5.00 \times 10^6$ mg)/5 mg/sec = 1.00×10^6 sec = 278 hr during which time all the water flowing at 10.0 L/sec over the container will become contaminated with 0.5 ppm of the pesticide. The distance downstream contaminated by the pesticide is 278 hr × 1 km/hr = 278 km.

7. Give a reason that Na_3PO_4 would not function well as a detergent builder, whereas $Na_3P_3O_{10}$ is satisfactory, though it is a source of pollutant phosphate.

Answer: Although both bind with calcium (water hardness), the anion of $Na_3P_3O_{10}$ forms a soluble chelate with Ca^{2+} ion whereas Na_3PO_4 forms a potentially troublesome precipitate of calcium phosphate.

8. Of the compounds $CH_3(CH_2)_{10}CO_2H$, $(CH_3)_3C(CH_2)_2CO_2H$, $CH_3(CH_2)_{10}CH_3$, and ϕ-$(CH_2)_{10}CH_3$ (where ϕ represents a benzene ring), which is the most readily biodegradable?

Answer: $CH_3(CH_2)_{10}CO_2H$ would be the most readily biodegradable because of its straight chain and carboxylic acid group, which is readily metabolized by bacteria forming progressively shorter chain acids and finally CO_2.

9. A pesticide sprayer got stuck while trying to ford a stream flowing at a rate of 136 liters per second. Pesticide leaked into the stream for exactly 1 hour and at a rate that contaminated the stream at a uniform 0.25 ppm of methoxychlor. How much pesticide was lost from the sprayer during this time?

Answer: Each second 136 L of water was contaminated by 0.25 mg/L pesticide so:

Mass pesticide = 136 L/sec × 3600 sec × 0.25 mg/L = 122,400 mg = 122 g

10. A sample of water contaminated by the accidental discharge of a radionuclide used for medicinal purposes showed an activity of 12,436 counts per second at the time of sampling and 8,966 cps exactly 30 days later. What is the half-life of the radionuclide?

Answer: Use the two formulas $A = A_0e^{-\lambda t}$ and

$$t_{1/2} = \frac{0.693}{\lambda}$$

where A_0 = 12,436 cps, A = 8966 cps and t = 30 days to calculate λ = 0.0109 day^{-1} and $t_{1/2}$ = 63.5 day

11. What are the two reasons that soap is environmentally less harmful than ABS surfactant used in detergents?

Answer: Soap precipitates from solution with Ca^{2+} ion and is much more biodegradable than ABS surfactant

12. What is the exact chemical formula of the specific compound designated as PCB?

Answer: PCBs have variable formulas with a number of congeners produced by substitution Cl for H on biphenyl.

13. Match each compound designated by a letter with the description corresponding to it designated by a number.

(a) CdS (b) $(CH_3)_2AsH$ (c)   (d)
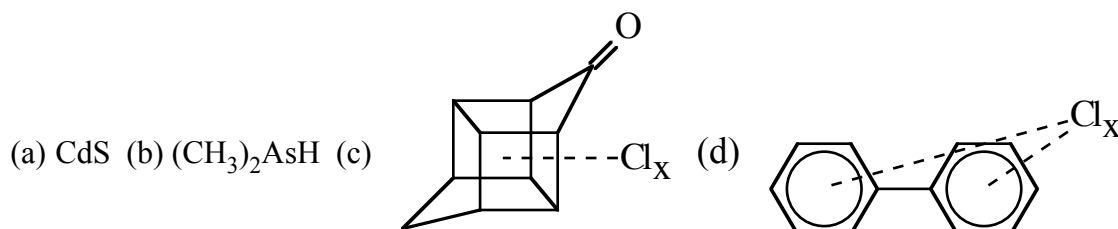
1. Pollutant released to a U.S. stream by a poorly controlled manufacturing process.

2. Insoluble form of a toxic trace element likely to be found in anaerobic sediments.

3. Common environmental pollutant formerly used as a transformer coolant.

4. Chemical species thought to be produced by bacterial action.

Answer: a-2, b-4, c-1, d-3

14. A radioisotope has a nuclear half-life of 24 hours and a biological half-life of 16 hours (half of the element is eliminated from the body in 16 hours). A person accidentally swallowed sufficient quantities of this isotope to give an initial "whole body" count rate of 1000 counts per minute. What was the count rate after 16 hours?

Answer: If the isotope had an "infinitely long" nuclear half-life, after exactly 1 biological half-life (16 hr) the whole body count rate would be 1000 cpm/2 = 500 cpm a value that can be taken as A_0 to calculate A after 16 hours in the relationship $A = A_0 e^{-\lambda t}$. Using the nuclear half-life of 24 hours, calculate $\lambda = 0.693/t_{1/2}$. A = 315 cpm.

15. What is the primary detrimental effect upon organisms of salinity in water arising from dissolved NaCl and Na_2SO_4?

Answer: Increased salinity causing harm due to osmotic effects

16. Give a specific example of each of the following general classes of water pollutants: (a) trace elements, (b) metal-organic combinations, (c) pesticides

Answer: (a) Arsenic in drinking water; (b) dimethylmercury, $Hg(CH_3)_2$; (c) atrazine agricultural herbicide in groundwater

17. A polluted water sample is suspected of being contaminated with one of the following: soap, ABS surfactant, or LAS surfactant. The sample has a very low BOD relative to its TOC. Which is the contaminant?

Answer: Both soap and LAS surfactants have relatively high BODs whereas ABS surfactant does not biodegrade well and is probably the contaminant.

18. Of the following, the one that is **not** a cause of, or associated with eutrophication is (A) eventual depletion of oxygen in the water, (B) excessive phosphate, (C) excessive algal growth, (C) excessive nutrients, (D) excessive O_2.

Answer: D

19. Match the pollutants on the left with effects or other significant aspects on the right, below:

    A. Salinity   1. Excessive productivity

    B. Alkalinity   2. Can enter water from pyrite or from the atmosphere

    C. Acidity   3. Osmotic effects on organisms

    D. Nitrate   4. From soil and mineral strata

Answer: A-3, B-4, C-2, D-1

20. Of the following heavy metals, choose the one most likely to have microorganisms involved in its mobilization in water and explain why this is so: (A) Lead, (B) mercury, (C) cadmium, (D) chromium, (E) zinc.

Answer: Mercury because of the formation of soluble methylated forms by anoxic bacteria

21. Of the following, the true statement (A) eutrophication results from the direct discharge of toxic pollutants into water, (B) treatment of a lake with phosphates is a process used to deter eutrophication, (C) alkalinity is the most frequent limiting nutrient in eutrophication, (D) eutrophication results from excessive plant or algal growth, (E) eutrophication is generally a beneficial phenomenon because it produces oxygen.
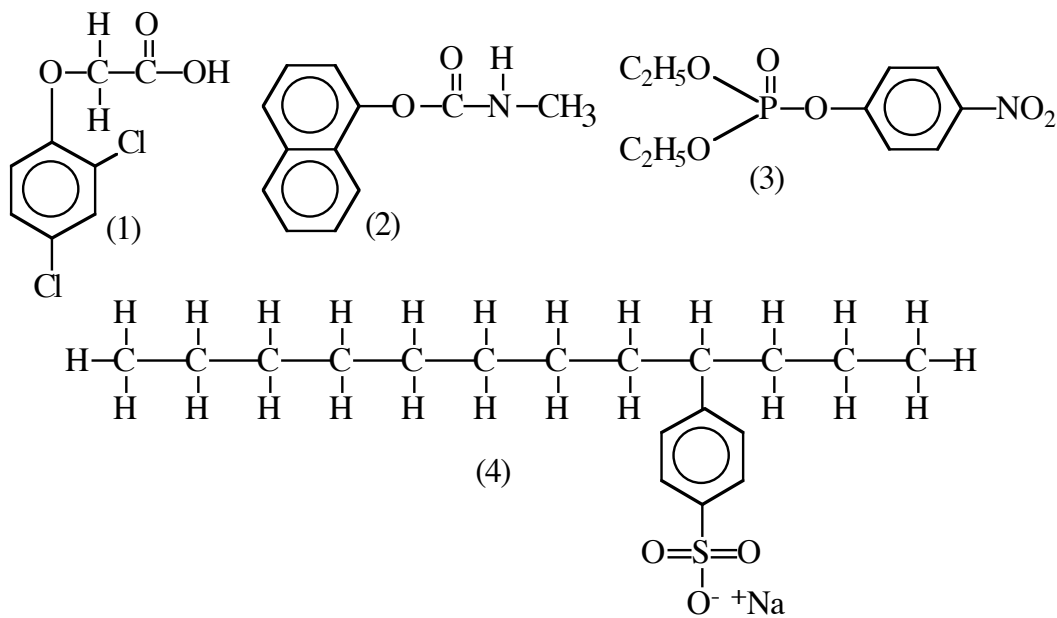
Answer: D

22. Of the following, the statement that is **untrue** regarding radionuclides in the aquatic

environment is (A) they emit ionizing radiation, (B) they invariably come from human activities, (C) radionuclides of "life elements," such as iodine-131, are particularly dangerous, (D) normally the radionuclide of most concern in drinking water is radium, (E) they may originate from the fission of uranium nuclei.

Answer: B

23. From the formulas below match the following: (A) Lowers surface tension of water, (C) a carbamate, (B) a herbicide, (D) a non-carbamate insecticide

Answer: A-4, B-1, C-2, D-3

24. Polychlorinated biphenyls, PCBs, (A) consist of over 200 congeners with different numbers of chlorine atoms, (B) are noted for their biological instability and, therefore, toxicity, (C) occur primarily as localized pollutants, (D) are not known to undergo any biodegradation processes, (E) had no common uses, but were produced as manufacturing byproducts.

Answer: A