FE REVIEW: ENVIRONMENTAL ENGINEERING Y. T. Wang

Chemical Equilibrium and Stoichiometry

1. The chloride ($C1^-$) concentration in a lake is found to be 10^{-2} M. The $HgC1_2$(aq) concentration is found to be 10^{-7} M. The following chemical equations and equilibrium constants apply.

   $Hg^{2+} + Cl^- \leftrightarrow HgC1^+$ $K_1 = 5.6 \times 10^6$

   $HgC1^+ + Cl^- \leftrightarrow HgC1_2$ $K_2 = 3.0 \times 10^6$

   The concentration of Hg^{2+} is most nearly

   (A) 5.9×10^{-17} M
   (B) 3.3×10^{-12} M
   (C) 3.0×10^6 M
   (D) 5.6×10^6 M

2. Nickel is removed by hydroxide precipitation from water with a pH of 9. The atomic weight of nickel is 58.70. The chemical equation and solubility-product constant for this reaction are

   $Ni^{2+} + 20H^- \rightarrow Ni(OH)_{2(s)}$ $K_{sp} = 5.54 \times 10^{-16}$

   The solubility of Ni^{2+} in this water is most nearly

   (A) 0.0060 mg/L
   (B) 0.33 mg/L
   (C) 0.55 mg/L
   (D) 0.59 mg/L

3. A water sample from a stream with an average flow of 95 000 L/d contains 225 mg/L of cyanide waste in the form of sodium cyanide (NaCN). Chlorine can be added to the stream to destroy this NaCN waste according to the reaction

$$2NaCN + 5C1_2 + 12NaOH \rightarrow N_2 + Na_2CO_3 + 10NaC1 + 6H_20$$

Atomic weights are found from a periodic table of the chemical elements to be Na = 22.989 77, C = 12.011, N = 14.0067, Cl = 35.453, O0 = 15.9994, and H = 1.0079.
The theoretical minimum amount of chlorine required to destroy the NaCN waste is most nearly

(A) 80 kg/d
(B) 160 kg/d
(C) 170 kg/d
(D) 200 kg/d

4. The chemical oxygen demand (COD) of octane is the amount of oxygen required to convert the compound to carbon dioxide and water. The molecular formula of octane is C_8H_{18}. The COD of octane is most nearly

(A) 3.5 g O_2/g octane
(B) 16 g O_2/g octane
(C) 23 g O_2/g octane
(D) 45 g O_2/g octane

5. The equation describing the overall conversion of ammonia to nitrate in pure water is as follows

$$NH_3 + 20_2 \longrightarrow HNO_3 + H_2O$$

The mass of oxygen required to complete the nitrification of 100 kg of ammonia is most nearly

(A) 190 kg
(B) 230 kg
(C) 380 kg
(D) 460 kg

6. The equilibrium constant, K_{eg}, is 5 x10^{-11} mol/L for the reaction

$$HCO_3^- \leftrightarrow H^+ + CO_3^{2-}$$

The molar concentration of HCO_3^- at a pH of 7.5 is most nearly

(A) 3.8x$10^{-1°}$ mol/L
(B) 4.0x10^{-5} mol/L
(C) 2.0x10^{-5} mol/L
(D) 1.0 mol/L

Chemical Reaction Rate and BOD

7. An experiment shows that 84% of fluchloralin in water photolyzes after 13 d of exposure to natural sunlight. If this reaction has first-order kinetics, the rate constant is most nearly

(A) 0.065/d
(B) 0.012/d
(C) 0.19/d
(D) 0.14/d

8. The reaction for a biologically degraded contaminant is first order. The half-life of the contaminant is 3 wk. The reaction rate is most nearly

(A) 0.033/d
(B) 0.041/d
(C) 0.15/d
(D) 0.23/d

9. A sample of wastewater is diluted by a factor of 1:10. The diluted wastewater has an initial dissolved oxygen concentration of 7.0 mg/L. After 5 d it has a dissolved oxygen concentration of 3.0 mg/L. The 5-day BOD of the initial undiluted wastewater is most nearly

(A) 3 mg/L
(B) 4 mg/L
(C) 7 mg/L
(D) 40 mg/L

10. A sample of wastewater has a kinetic rate constant of 0.1/d. The initial dissolved oxygen reading is 8.00 mg/L. The reading after 2 d without any additional oxygen being added is 6.00 mg/L. Therefore, the ultimate BOD is most nearly

(A) 2.0 mg/L
(B) 9.0 mg/L
(C) 11 mg/L
(D) 21 mg/L

Water Quality and Water Treatment

11. A sample of water has the following cation concentrations.

Cation	Concentration (mg/L)
Na	10
Ca	20
Mg	20

The total hardness of the water is most nearly

(A) 20 mg/L $CaCO_3$
(B) 40 mg/L $CaCO_3$
(C) 130 mg/L $CaCO_3$
(D) 140 mg/L $CaCO_3$

12. The solids loading rate for a 30.5 m diameter clarifier with a flow rate equal to 5 MGD and an influent suspended solids (SS) equal to 150 mg/L is most nearly

(A) 1.1 $kg/d \cdot m^2$
(B) 2.2 $kg/d \cdot m^2$
(C) 3.9 $kg/d \cdot m^2$
(D) 4.2 $kg/d \cdot m^2$

13. A wastewater treatment plant discharges 1.10 m^3/s of treated effluent having an ultimate BOD of 50.0 mg/L into a stream that has a flow of 8.70 m^3/s and a BOD 6.0 mg/L. The deoxygenation constant, k_d, is 0.20/day.

a. Assuming complete and instantaneous mixing, estimate the ultimate BOD of the river just downstream from the outfall.
b. If the stream has a constant cross section, so that it flows at a fixed speed equal to 0.30 m/s, estimate the BOD remaining in the stream at a distance 30,000 m downstream.

14. A town of 30,000 sends 0.5 m^3 of wastewater per person per day to the wastewater treatment plant. A conventional circular primary clarifier has an average detention time of 2.0 hours and an average overflow rate of 40 m/d. What would be the dimensions of the clarifier?

Landfill Design

15. A proposed landfill is to be 400 m x 200 m in plan area and 25 m deep. The average daily filling pattern is expected to be 15 m x 10 m x 3 m deep, and the daily cover to be used is 0.2 m thick. Assume that the landfill will be operational every week from Monday through Friday.

    The projected life of the landfill is most nearly

    (A) 16 yr
    (B) 17 yr
    (C) 20 yr
    (D) 23 yr