

1. A city discharges 44,000 cubic meter of sewage (BOD_5 5,500 kg/day, D.O. 0 mg/L) daily into a near-by stream. The stream just above the point of sewage discharge has a flow rate of $6 \text{ m}^3/\text{s}$, D.O. 6.0 mg/L, and BOD_5 0 mg/L. After mixing, the stream and sewage flow at a velocity of 0.30 m/s. Assume the temperature of the stream and wastewater is 20 C. The deoxygenation (k_1) and reaeration (k_2) coefficient are 0.25 and 0.40 day^{-1} , respectively. The Henry's Law constant of oxygen at 20 C is $4.01 \times 10^4 \text{ atm/mole fraction}$. Try to find:

(1) The initial oxygen deficit (assuming the complete mixing of the sewage and stream is instantaneous)

(2) The dissolved-oxygen concentration in the stream at point 30 km from point of discharge. (20%)

$$\left[D = \frac{k_1 L_0}{k_2 - k_1} (e^{-k_1 t} - e^{-k_2 t}) + D_0 e^{-k_2 t} \right]$$

2. Sketch a flow diagram of an activated sludge treatment process, and give a description of its operation. What is *sludge bulking*? How is the SVI (sludge volume index) related to bulking? How may bulking be controlled? (20%)

3. Give the most common sewage sludge treatment process, and describe the function of each step. (10%)

4. (1) What are *Giardia* and *Cryptosporidia*? What are their impacts on public water supply?

(2) Sketch a flow diagram of a conventional water treatment process. How can the breakthrough of *Giardia* and *Cryptosporidia* in a conventional water treatment process be prevented? (20%)

5. Compare the advantages and disadvantages of using chlorine and ozone as primary disinfectants for drinking water treatment. (10%)

6. How are mudballs formed in a rapid sand filter? Explain their effect on filter performance, and how can the mudballs formation be prevented? (10%)

7. (1) What are the major mechanisms of colloid destabilization in coagulation process?

(2) Based on the mechanisms of colloid destabilization, explain the reason behind the practice in water industry that when treating low turbidity source water, in order to reduce coagulant dosage, clay may be added into raw water before coagulation. (10%)