

ORDRE DES INGÉNIEURS DU QUÉBEC

May 2023 SESSION

Open-book examination
Calculators : only authorized models
Duration : 3 hours

14-EN-A1 PRINCIPLES OF ENVIRONMENTAL ENGINEERING

PART I : PROBLEM SOLVING (49 %)

QUESTION 1 (20 marks)

- a- (10 marks)** An accident has caused a substantial spill of hydrocarbons in soil where the volume of contaminated soil is 2548.5 m^3 . Estimate the mass of hydrocarbons (TPH) in the contaminated soil, if the average hydrocarbon concentration in soil is $1,000 \text{ mg/kg}$, and the soil bulk density is 1.75 g/cm^3 .
- b- (10 marks)** The decontamination of this soil will be done by using the biopile technology which uses microbial processes. Estimate the nitrogen and phosphorus requirements (mg/kg soil) for the decontamination of this soil by the biopile technology by assuming 85% carbon in the TPH and a required C:N:P ratio of 100:10:1.

QUESTION 2 (5 marks)

A solution contains a chemical compound with the formula of $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ at the concentration of 200 mg/L . Calculate the chemical oxygen demand (COD) of this solution in mg/L .

QUESTION 3 (15 marks):

- a) **(8 marks)** A chemical treatment plant uses 300 kg of a specific polyelectrolyte for coagulation purposes each day. The appropriate concentration of coagulant has been determined by jar tests. Estimate the flow rate of water to the plant if jar tests indicate that one liter of water requires the addition of 4 mL of a 10 mg/L solution of polyelectrolyte.
- b) **(7 marks)** How much Ferric chloride should be used per month instead of the polyelectrolyte coagulant if optimum coagulation during the jar tests that use 1L water occurs with 3 mL of a 9 mg/L solution of ferric chloride?

QUESTION 4 (9 marks):

The treatment of groundwater contaminated with phenol has been conducted in a bioreactor by using microbial processes. Determine the growth yield coefficient during the biodegradation of phenol by the bacterial culture in this bioreactor, using the Monod kinetics for microbial biodegradation and the following data:

- Specific biodegradation rate of phenol (q): 0.4 d^{-1}
- Maximum specific growth rate (μ_{\max}): 0.24 d^{-1}
- Half saturation constant (K_s): 8 mg/L
- Phenol concentration in the bioreactor (S): 56 mg/L

PART II- KNOWLEDGE-BASED QUESTIONS (51%) (3.0 marks each question)

1. What are the definitions of free residual chlorine and combined residual chlorine during water disinfection?
2. Name two methods for solid-liquid separation in wastewater treatment operations.
3. What property of biological sludge is represented by the Sludge Volume Index (SVI)? Briefly describe the procedure for the measurement of this parameter.
4. Name three potential terminal electron acceptors in anaerobic biological processes.

5. What could be a proper carbon source for the growth of microorganisms during the nitrification process?
6. Name two water parameters that promote the corrosion of metals in water.
7. State three advantages and three disadvantages (limitations) of UV technology for water disinfection.
8. What are trihalomethanes? How are they formed during drinking water treatment operations?
9. During *in situ* bioremediation processes for the decontamination of soil, suggest three methods for the supply of oxygen to the microbial population in soil.
10. What are the major constituents of alkalinity in water?
11. Name two sources of color in surface waters (lakes and rivers).
12. What is the objective of sludge thickening process in a wastewater treatment plant? State three methods of sludge thickening.
13. Explain what air pollutants and environmental conditions are necessary for the formation of photochemical smog (PCS). What are the environmental and health concerns caused by PCS?
14. Name three different sources of particulate matter (PM) in air. Explain at least one health hazard of PM in air.
15. From the list below (a, b, c or d) choose two pollutants which cause man-made air pollution:
 - a. Nitrogen and carbon dioxide
 - b. Carbon monoxide and nitrogen oxide
 - c. Carbon monoxide and nitrogen
 - d. Oxygen and carbon dioxide
16. What substances contribute to the hardness of water? What is the effect of hard water in a water distribution network?
17. Name two methods for the removal of phosphorus from wastewater. Briefly describe the mechanisms of phosphorus removal by these methods.