ORDRE DES INGÉNIEURS DU QUÉBEC

May 2018 SESSION

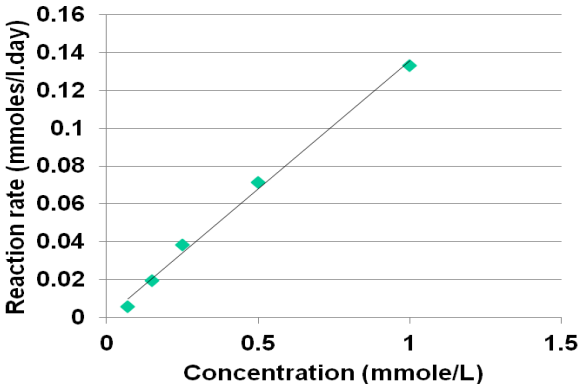
Open-book examination
Calculators : only authorized models
Duration : 3 hours

14-EN-A1
ENVIRONMENTAL ENGINEERING PRINCIPLES

PART I : PROBLEM SOLVING (51 %)

QUESTION 1 (20 %)

The data in the following graph show the removal of phenol from a contaminated site.



Determine:

a) **(5 points)** The order of reaction that governs the removal of phenol at this site.

b) **(5 points)** The rate constant (d^{-1})

c) **(5 points)** The half-life of the disappearance of phenol (days).

d) **(5 points)** If the phenol concentration at the site is 120 µmoles/L on May 12, what would be the phenol concentration on September 16 of the same year?

QUESTION 2 (20%):

A water treatment plant uses 3 kg/day alum for coagulation purposes in a water stream that has 100 mg/L suspended solids, and produces sludge that requires removal and further treatment. The amount of dry sludge produced during the coagulation process may be estimated from the following equation:

$$M_s = 86.4\ Q\ (0.44\ A + SS + M)$$

Where:

M_s = Dry sludge produced (kg/d)
Q = Water flow rate (m^3/sec)
A = Alum dose (mg/L)
SS = Suspended solids in the water (mg/L)
M = Chemical additions such as clay and polymers

If no other chemical than alum is used in the treatment process and the jar test indicates that 1 liter of water requires 4 mL of a 10 mg/L solution of alum, determine the following:

a- (10 points) The flow rate of water to the plant (m^3/sec).
b- (10 points) The quantity of dry sludge generated in the treatment plant per year (kg/year).

QUESTION 3 (11%):

During the disinfection of drinking water by chlorine, the value of K in the Watson equation for 99.8% kill was found to be equal to 312, and the destruction of microorganisms followed the Chick's relationship, as follows:

Chick's equation; $dN/dt = - k\ N$
Watson equation: $C^n\ t = K$ (assume $n = 1$)

Where:

N = Number (or concentration) of pathogens at time t
t = Time (min)
C = Concentration of disinfectant (mg/l)
k = Rate constant (min^{-1})

Determine the following:

- **(11 points)** The K(99% kill) for the same operating conditions and using the same disinfectant concentration.

PART II- KNOWLEDGE-BASED QUESTIONS (49%)

Questions (3.5 marks each)

1. What typical chemical compounds are produced as a result of biological degradation processes in an anaerobic lagoon?

2. During the disinfection processes, what is the purpose of dechlorination process? How is it accomplished?

3. Why is hard water desirable in a water treatment process if phosphorus is present as a contaminant?

4. What are two principle methods of oxygen supply in naturally-aerated lagoons?

5. Which one of the following compounds cannot be used as the terminal electron acceptor during anaerobic respiration?

    a) sulfate (SO_4^{2-})
    b) nitrate (NO_3^-)
    c) hydrogen sulfide (H_2S)
    d) iron (Fe^{2+})

6. What gas filters out UV radiation in the earth's atmosphere?

7. What are the three major gases found in air? (choose one of the following: a, b or c)

    a) Methane, oxygen, carbon dioxide
    b) Nitrogen, oxygen, carbon dioxide
    c) Oxygen, argon, nitrogen

8. Which of the following is the least desirable pollution prevention strategy?

    a) source reduction
    b) incineration
    c) recycling
    d) waste treatment
    e) disposal

9. Name three methods for the disinfection of drinking water.

10. What types of contaminants are targeted to be removed during the tertiary treatment stage in a wastewater treatment plant?

11. Identify two greenhouse gases and provide two engineering measures (one for each greenhouse gas) that may be used to reduce these emissions to the atmosphere.

12. Briefly explain the main cause(s) of acid rain, and provide two engineering solutions to reduce the production of acid precipitation.

13. Name two major atmospheric emissions produced by coal-fired power plants.

14. State two physical-chemical properties of a chemical contaminant that will help an environmental engineer determine its partitioning in a water-soil mixture.