ORDRE DES INGÉNIEURS DU QUÉBEC

SESSION DE NOVEMBRE 2017

Toute documentation permise
Calculatrices : modèles autorisés seulement
Durée de l'examen : 3 heures

16-CH-B1
ENVIRONMENTAL ENGINEERING

Question 1 (5 points)

A (2 points) – Consider a lake in Southern Quebec. Is there a season of the year during which the water in this lake is more saturated with oxygen than the others? Please give a rational explanation for your answer.

B (2 points) – What are the roles of ozonation in drinking water production plants?

C (1 point) – Do microfiltration membranes allow the removal of cryptosporidium oocysts? Explain why.

Question 2 (total 10 points)

A water contains the following nitrogenous substances:

Total nitrogen : 50 mg/L ,expressed as N
ammoniac NH_3 and ammonium NH_4^+ : 45 mg/L expressed as NH_3,
nitrate : 8 mg/L expressed as NO_3,
nitrite : 0.2 mg/L expressed as NO_2.

a) (3 points) – Determine whether this water meets the Quebec standard for drinking water for nitrates and nitrites (i.e. 10 mg / L nitrates + nitrites expressed in N).

b) (3 points) Calculate the organic nitrogen concentration in this water in mg N / L.

c) (4 points) What will be the quantitative impact of the presence of nitrates on the measurement of total BOD (including carbonaceous and non-carbonaceous BOD)?

Question 3 (total 20 points)
A midnight dumper discharged a tank truck full of industrial waste in a gravel pit. The truck was spotted 3 days ago, and a pool of pure waste remains. A laboratory technician determined that the waste has a BOD_5 of 80 mg l^{-1} with a first order rate constant of 0.1 day^{-1}. Three factories in the vicinity generate organic wastes: a winery (ultimate BOD (BODu = 275 mg l^{-1}); a vinegar manufacturer (BODu = 80 mg l^{-1}), and a pharmaceutical company (BODu = 200 mg l^{-1}). Determine the source of the waste.

Question 4 (total 25 points)
A completely mixed flow reactor (CMFR) is used to treat an industrial waste, using a chemical reaction that remove the targeted contaminant according to a first order kinetics, with the kinetics constant = 0.216 day^{-1}. The reactor volume is 500 m^3, the flowrate of the reactor is 50 m^3 day^{-1}, and the inlet concentration is 100 mg l^{-1}. What is the outlet concentration after treatment?

Determine the volume required for a plug flow reactor (PFR) to obtain the same pollutant reduction as the CMFR. Assume that the flowrate and kinetics constant are the same.
Please state your assumptions.

Question 5 (15 points)
A water-unsaturated aquifer composed of silty sand has a porosity of 0.3 and a density of 2300 kg / m3. A soil analysis revealed a concentration of benzene of 1.2 ppm and organic carbon of 0.5%. The linear sorption coefficient of benzene in this soil is 0.92 (mg/kg)/(mg/L).

A) (5 points) How does this soil contamination compare to MDDELCC contamination criteria, and explain what it means.

	MDDELCC's soils quality criteria		
	A	B	C
Benzen (mg/Kg)	0,1	0,5	5

B) (10 points) If the aquifer becomes saturated with water and the groundwater is stagnant, determine, by calculation, whether the concentration of benzene in the groundwater will allow the use of this water for human consumption according to Quebec's criteria.

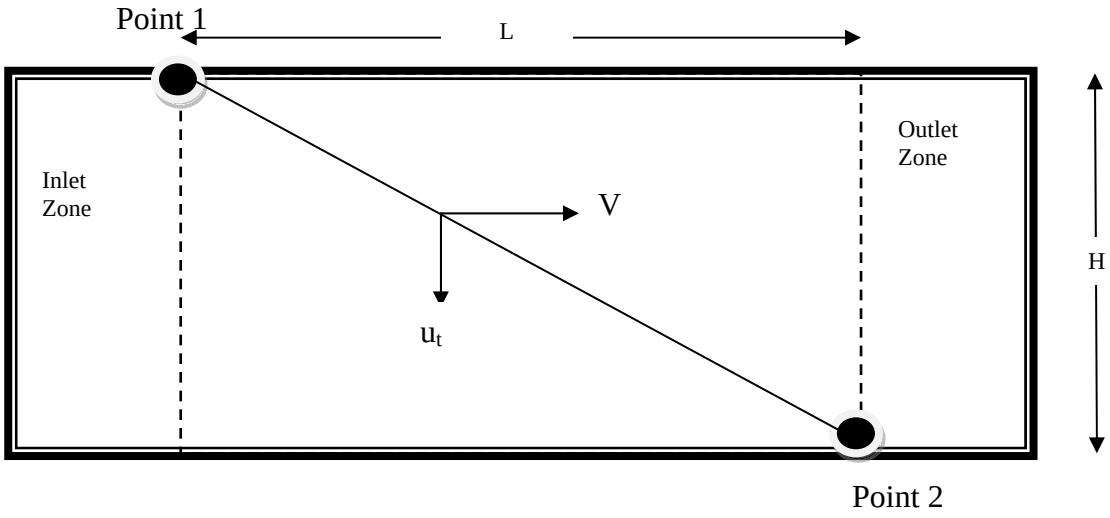
		MDDELCC's Groundwater Criteria (µg/L)	
	Limit of quantification (LQM) (µg/L)	Drinking water criteria	RESURGENCE IN SURFACE WATERS OR INFILTRATION IN SEWER SYSTEM
Benzene	0,2	5	590

Question 6 (25 points)

In an ideal rectangular sedimentation tank (see Figure 1) where the width *l*, the length *L* and the depth *H*, a particle entering point 1 must be removed by sedimentation. To do so, this particle has to reach point 2. This particle has a horizontal velocity of *V* and a sedimentation velocity of u_t.

A) (15 points) With these information, could you demonstrate that the sedimentation velocity (u_t) is equal to the filtration rate (Q/A) typically used as the conception criteria? What are the assumptions made? What are the practical implications of that result on the theoretical design of a clarifier?

Figure 1. Ideal rectangular sedimentation tank



B) (10 points) Calculate the sedimentation velocity (u_t) of sand particles in water. These particles have a diameter of 0.001 cm, a relative density of 1.65, and a sphericity of 1,0. If the temperature of water is 10°C, what would be the filtration rate of the clarifier needed to remove these particular particles (density of water = 999.7 kg m^{-3}; dynamic viscosity = $1.307*10^{-3}$ N*s m^{-2})? Using that design criteria, what would be the dimensions of a sedimentation tank designed to treat 10 000 m3 day^{-1}? Assume that the depth of your sedimentation tank is 3m and the length: width ratio is 4:1.