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CVG 2532 – PRINCIPES DE BASE DU GÉNIE DE L'ENVIRONNEMENT EXAMEN FINAL

SECTION A – 10 QUESTIONS À CHOIX MULTIPLE (2 POINTS CHACUN – TOTAL DE 20 POINTS):

1. Acidity is defined as:

- (A) a solution having a pH less than 7
- B) a solution with a pH greater than 7
- C) the ability of a solution to resist changes in pH due to the addition of base
- D) the ability of a solution to resist changes in pH due to acid

2. A lake with a low level of productivity due to a very limited supply of nutrients is:

- A) Eutrophic
- B) Oligotrophic
- C) Mesotrophic
- D) None of these responses

3. Bioaccumulation is problem that is a particularly environmental concern for what type of contaminants:

- A) a highly caustic pollutant is released into a Lake
- B) a hydrophobic pollutant is discharged into a Lake
- C) a pollutant with a high octanol-water partition coefficient is released in a Lake
- D) a pollutant with a low octanol-water partition coefficient is released into a Lake

4. A fundamental assumption in the development of the Streeter-Phelps equation for the collapse of the dissolved oxygen (DO) is:

- A) the river behaves as a completely mixed reactor (CSTR)
- B) the river behaves as a plug-flow reactor (PFR)
- C) River behaves as a batch reactor (batch)
- D) all of the above
- E) none of the above

5. Three bottles to DBO containing samples from the same source of water are evaluated. After 5 days of incubation in darkness, you notice that air has entered one of the bottles. Assuming that the plug has not been properly installed prior to incubation, you expect that:

- A) the three bottles will have the same values of BOD and DO
- B) the DO of the bottle with the CAP loose will be lower than that of the other
- C) the BOD of the bottle with the loose CAP will be more high the others
- D) the BOD of the bottle with the loose CAP will be lower than the others

6. If two samples have the same BOD_U , these samples must also:

- (A) had the same BOD_5
- B) had the same reaction constant
- C) had the same temperature
- D) all of these responses
- E) none of these responses

7. Two contaminants, A and B, with a factor of delay (R) of 1.5 and 3.2, respectively, pollute an aquifer underground. How these contaminants move in the aquifer?

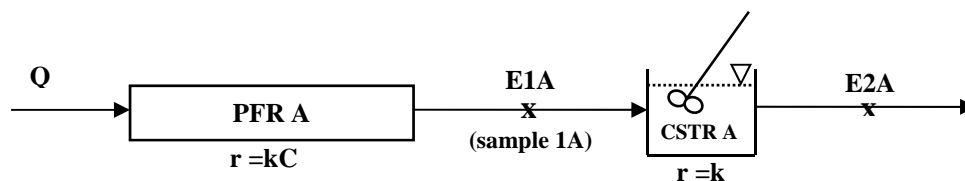
- A) A and B will move at the same speed
- B) A move at a higher rate than B
- C) B will move at a higher rate that A
- D) A and B are stationary and do not move
- E) A will decompose at a higher rate than B
- F) A will decompose at a slower rate than B

8. Two continuous wastewater treatment systems are considered for the removal of BOD.

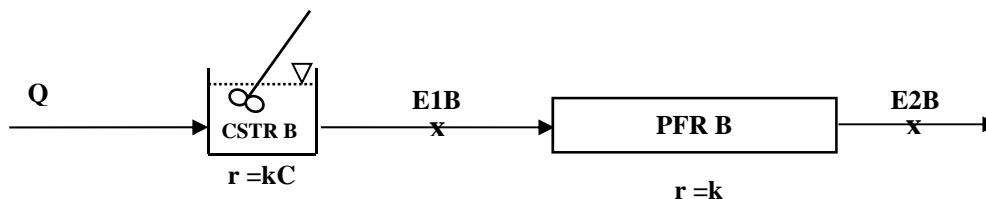
A laboratory study determines that the degradation of the BOD will follow a first order reaction ($r = kC$) in the first reactor of a treatment system and a zero ($r = k$) order reaction in the second reactor of the system. See the diagrams below

Company JIT recommends the installation of a reactor PFRS (PFR A) followed a reactor CSTR (CSTR A). Company APEX recommends the installation of a reactor CSTR (CSTR B) followed a PFR (PFR B) reactor. Four reactors have the same volume. The flow of waste water (Q) is the same in both cases. Assume that the system is at steady-state. Answer questions 8A, 8B and 8 relate to the BOD concentrations at the sampling points shown for each system.

Company JIT:



Company APEX:



8a. Identify the correct answer based on the concentration of the samples collected at points E1A and E1B [] brackets indicate a concentration

- A) $[E1A] = [E1B]$
- B) $[E1A] < [E1B]$
- C) $[E1A] > [E1B]$
- D) None of the above

8b. Identify the correct answer based on the concentration of the samples collected at points E2A et E2B

- A) $[E2A] = [E2B]$
- B) $[E2A] < [E2B]$
- C) $[E2A] > [E2B]$
- D) Aucune de ces réponses

8c. Identify the correct answer based on the concentration of the samples collected at points points E1A, E2A et à l'intérieur du réacteur CSTR A

- A) $[E1A] = [CSTR A]$
- B) $[E2A] = [CSTR A]$
- C) $[E1A] < [CSTR A]$
- D) $[E2A] < [CSTR A]$

SECTION B – RÉPONSES MOYENNES / LONGUES (5 QUESTIONS – TOTAL DE 80 POINTS)

1. (10 points) A waste water sample is diluted by a factor of 100 with of the dilution water to determine the carbonaceous BOD (CBOD). The concentration of dissolved oxygen (DO) is measured in the sample bottle and bottle control. The results are given below.

From these data:

- i) determine the BOD_5 of water
- ii) determine the ultimate BOD (BOD_U) of water

Time (days)	DO concentration in the diluted sample (mg/L)	DO concentration in The control (mg/L)
0	8.55	8.75
1	7.95	8.70
2	7.35	8.66
3	7.00	8.61
4	6.75	8.57
5	6.50	8.53
6	6.25	8.49
7	6.00	8.46
9	5.50	8.43
11	5.00	8.40
15	4.50	8.38
17	4.00	8.37
19	3.50	8.34
21	3.10	8.30
23	2.80	8.30
25	2.55	8.24
27	2.35	8.20
30	2.20	8.20
33	2.10	8.17
35	2.05	8.14
37	2.05	8.14
39	2.05	8.14

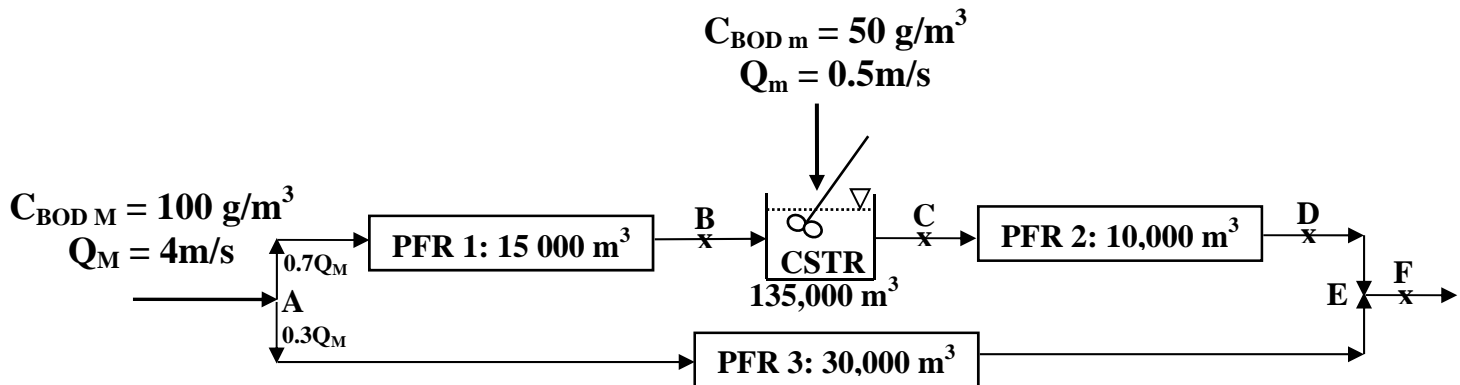
2. (20 points) The City of Havasplitflo's wastewater treatment plant has two influential streams. The main influential flow (Q_M) of $4 \text{ m}^3/\text{s}$ has a concentration of carbonaceous BOD (CBOD_M) of $100 \text{ g}/\text{m}^3$ at the head of the plant. A minor influential flow (Q_m) of $0.5 \text{ m}^3/\text{s}$ with a concentration of BOD (CBOD_m) of $50 \text{ g}/\text{m}^3$ directly enters a CSTR reactor in the middle of the plant. See the diagram below.

At the head of the plant wastewater flow splits into two streams. The main (upper) stream or channel has a flowrate of 70% of the Q_M and 30% of Q_M passes through the bottom channel. The upper channel ($0.7Q_M$) consists of a PFR reactor (PFR 1) with a volume of $15,000 \text{ m}^3$ followed a CSTR reactor (with a volume of $135,000 \text{ m}^3$) and finally another PFR reactor (PFR 2) with a volume of $10,000 \text{ m}^3$. The lower channel ($0.3Q_M$) consists of a single PFR reactor (PFR 3) with a volume of $30,000 \text{ m}^3$.

A minor additional flow (Q_m) enters directly in the CSTR reactor within the upper channel.

Upper and lower tract mix E junction. Assume steady state conditions prevail that we are at steady – state. Assume that in all reactors, the biodegradation of the BOD can be described by a first-order reaction ($r_{\text{BOD}} = -k \cdot \text{CBOD}$) and $k = 0.5 \text{ day}^{-1}$.

Determine the concentration of the CBOD to points B, C, D, and F under these conditions.



3. (20 points) Ion concentration for raw water is given below. The units for the ions and compounds concentration values reported are in mg/L.

TASKS:

- A)** Convert the concentrations of ions and compounds in the table in units mg/L as CaCO_3 . Show at least one set of detailed sample calculations with all the units.
- B)** Determine the application of lime and soda in mg/L as CaCO_3 for softening water in a final hardness of 80.0 mg/L as CaCO_3 . The application of lime in excess is 20 mg/l CaCO_3 . The limit of solubility of CaCO_3 and $\text{Mg}(\text{OH})_2$ in the process of treatment is 40 mg/L CaCO_3 . The pH of the water is 7.8.

Ion	Concentration (mg/L)	Concentration (mg/L CaCO_3)
Ca^{2+}	96	
Mg^{2+}	14.6	
Na^+	20.7	
HCO_3^-	219.6	
SO_4^{2-}	19.2	
Cl^-	103	
CO_2	6.6	

4. (15 points) A stream of industrial wastewater effluent is discharged into the Ottawa River. See the effluent and river characteristics in the table below.

TASKS:

- (A) Calculate the dissolved oxygen concentration (mg/L) in the Ottawa River immediately after the point of mixing. State all assumptions necessary to perform the calculation.
- B) Calculate the initial DO deficit (mg/L).
- C) Calculate the distance (km) downstream from the discharge where the DO is critical if the Ottawa River downstream of the discharge average speed is such that the speed upstream of the discharge.

	Industrial Effluent	Ottawa River (upstream of effluent discharge)
Flowrate (m³/s)	0.33	5.66
BOD at 20°C (mg/L)	450	1.05
DO (mg/L)	0.0	8.3
k_d at 20°C (day⁻¹)	N/A	0.22
k_r at 20°C (day⁻¹)	N/A	0.78
Flow velocity (m/s)	N/A	0.55
Temperature (°C)	18	12

5. (15 points) Consider a groundwater plume in rectangular form (simplification). The plume has 350 m thick (width). The aquifer thickness (depth) is average of 15 m, a porosity of 25% and a current pore speed of 4.1×10^{-3} cm/s and a hydraulic conductivity of 4000 m/d. The pumping rate which is extracted from the well is $0.1 \text{ m}^3/\text{s}$.

- A)** Will the well capture the contaminant? Yes/No, show your work
- B)** At what distance (in m) before the contaminated plume recommend you place well?
- C)** And after the information provided, what material (soil type) will you find on this site?

SECTION C – QUESTIONS BONIES (3 QUESTIONS – TOTAL DE 5 POINTS)

1. For a problem of mass balance, the case where the rate of accumulation is zero is called:
2. Name two major objectives of the restoration technology pump & treat.
3. Explain why the bioremediation is favoured when remediating (restoration of ground and groundwater) a contaminated site.