uOttawa

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CVG 2132

Fundamentals of Environmental Engineering

MIDTERM 2011

Professor: R. Delatolla

GIVEN NAME: ____

SURNAME: ____

STUDENT NUMBER: ____

- 10 PAGES & 4 QUESTIONS
- CLOSED BOOK EXAM
- NO PROGRAMMABLE CALCULATORS
- READ THE QUESTIONS CAREFULLY
- ANSWER THE QUESTION DIRECTLY ON MIDTERM
- BE MINDFUL OF TIME LIMIT
- TOTAL MARKS = 100
- WRITE LEGIBLY AND NEATLY
- CLEARLY STATE ALL ASSUMPTIONS
- GOOD LUCK!

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1. (15 marks) Provide answers to the multiple choice questions in the space provided below.

WRITE YOUR ANSWERS TO QUESTIONS (a), (b), (c), (d) & (e) HERE:

(a) =

(b) =

(c) =

(d) =

(e) =

(a) (3 marks) In addition to being a major sources of our drinking waters in Canada, lakes and rivers house essential ecosystems around the world. Select the only valid answer that pertains to nitrogen cycle in a lake.

i) ammonification is the biologically mediated hydrolysis of nitrogen-gas to ammonia.

ii) pathways of removal of nitrate (NO_3^-) include denitrification, synthesis and volatilization.

iii) pathways of production of organic nitrogen include synthesis and nitrification.

iv) fixation is a pathway of ammonia (NH_3/NH_4^+) production, which is a readily available form of nitrogen for biological synthesis.

v) none of these answers.

(b) (3 marks) Solids are an important water quality that must be accounted for in many water and wastewater treatment processes. Select the only valid answer.

i) FSS do not ignite at 104°C but they do ignite at 550°C.

ii) TSS do not ignite at 104°C but they do ignite at 550°C.

iii) TDS are comprised of the suspended, colloidal and dissolved matter.

iv) VSS do not ignite at 104°C but they do ignite at 550°C.

v) none of these answers.

(c) (3 marks) The carbonate buffering capacity of water is an important process in natural waters. For natural waters open to the atmosphere, select the only valid answer.

i) high carbonate buffering capacity = acidic water.

ii) CO_2 stripping increases the pH of the water.

iii) high carbonate buffering capacity = basic water.

iv) CO_2 bubbling increases the pH of the water.

v) none of these answers.

(d) (3 marks) Tracer test observations can be used to identify a PFR from other reactors. Select the only valid answer that pertains to the tracer study of a PFR.

i) the tracer becomes completely mixed longitudinally in the reactor .

ii) for an instantaneous pulse injection, the tracer concentration at the exit will be measurable only after one HRT and for 4 consecutive HRTs thereafter.

iii) for an instantaneous pulse injection, the tracer concentration that exits the PFR will be measurable at one HRT.

iv) an equation to predict the tracer concentration at the exit of the reactor can be developed by performing a mass balance on the reactor and assuming first order kinetics.

v) none of these answers.

(e) (3 marks) The carbonate hardness is equal to the total hardness when (select the only valid answer):

i) the alkalinity is more than the total hardness.

ii) the alkalinity is more than the carbonate hardness.

iii) the noncarbonated hardness is not = zero.

iv) the alkalinity is negligible.

v) none of these answers.

2. (20 marks) Provide answers to the short answer questions (a), (b) & (c) in the space provided below the questions.

NOTE: ANSWERS NEED ONLY BE ONE WORD LONG

(a) (6 marks) Name the three DOMAINS in the Domain System of Classification of cellular life:

(i)

(ii)

(iii)

(b) (6 marks) The release of gaseous carbon in the form of carbon dioxide and methane has been an environmental concern for many decades. The introduction of world carbon credits has given this environmental problem an economical importance. Provide the answers to the following questions below:

(i) WHERE does the current, greatest reservoir of carbon exist on Earth?

(ii) NAME the two systems (i.e. "pumps") that replenish this reservoir.

(c) (8 marks) According to the described characteristics below, CLASSIFY the following organisms (remember answers need only be one word long):

(i) Organisms that use light as an energy source:

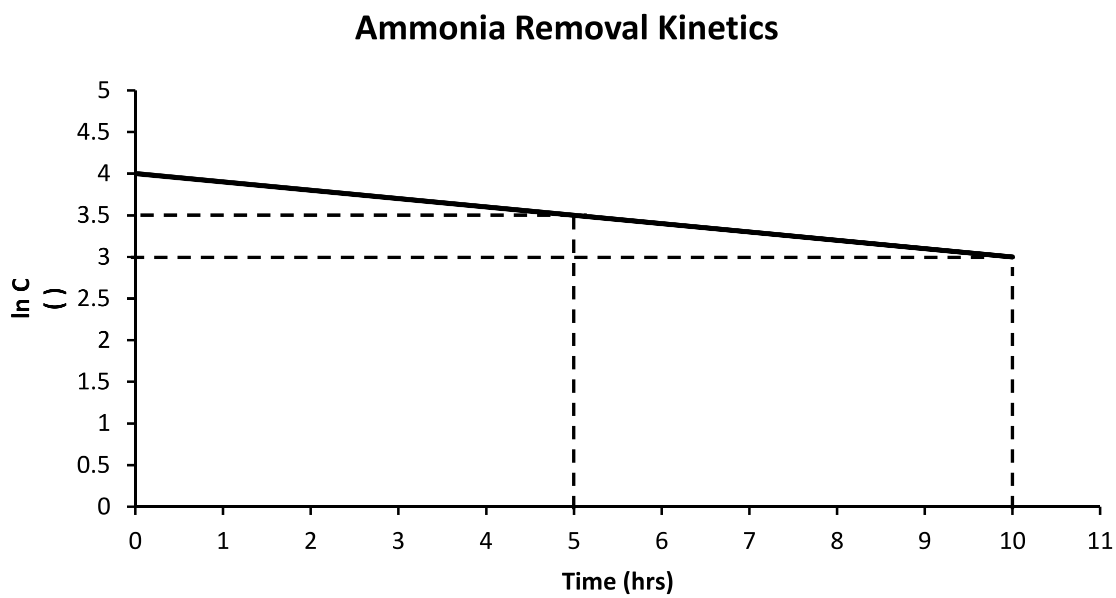
(ii) Organisms that use organic chemical compounds as a carbon source:

(iii) Organisms that use organic chemical compounds as an electron donor:

(iv)) Organisms that use oxygen as an electron acceptor:

3. (65 marks) Answer questions (a), (b), (c) & (d) in the space below (show all work and write legibly):

(a) (10 marks) Answer the following questions based on the batch, experimental data shown in the graph below:



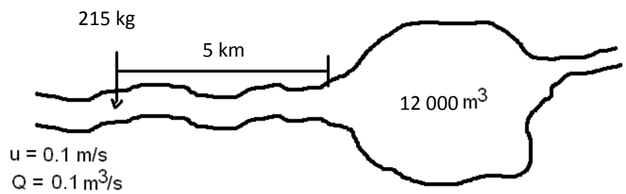
(i) what is the order of the reaction?

(ii) is the reactant being produced or consumed?

(iii) calculate the kinetic coefficient (k) of the reaction (remember units and sign).

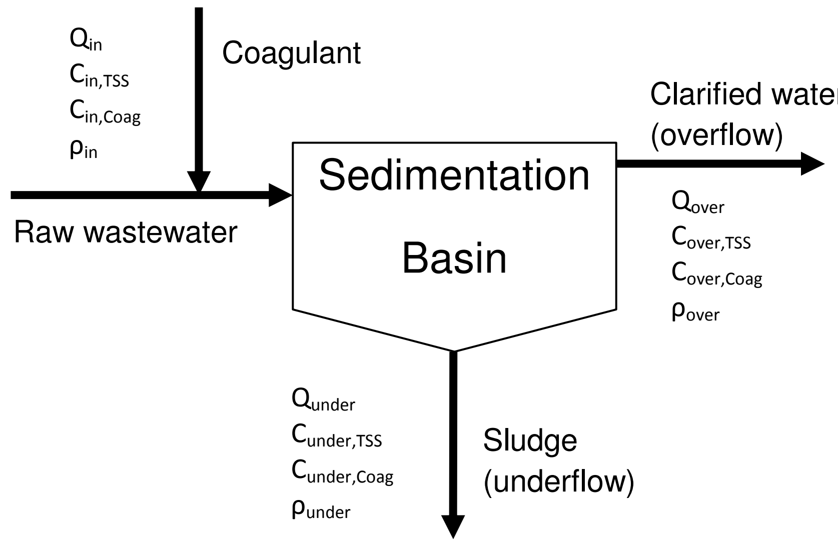
(b) (15 marks) An industrial spill released 215 kg of concentrated xylene into a river approximately 5 km upstream of a lake that is used for recreational activities. The total mass of xylene was released very quickly and can be interpreted as an instantaneous release into the river. If the lake was immediately closed for recreational activities following the spill and the recreational toxicity limit of xylene in lakes is 45 ppb, approximately how many days following the spill can the lake be re-opened for recreational activities. The velocity and flow rate of the river are given in the schematic.

Assume the lake behaves as a CSTR; the river behaves as a PFR; xylene is nonreactive & both the river and lake are dilute.



(c) (15 marks) The schematic below shows a clarifier treatment system that is used to remove suspended solids (measured as TSS) out of solution by gravitational settling enhanced with the addition of a coagulant.

- The system is operating with steady flow rates and steady influent concentrations.
- The solids and coagulant can be considered inert constituents.
- The flow rate of the coagulant stream is negligible compared to the influent stream.
- The concentration of coagulant in the outflow is negligible.
- The densities of the inlet and overflow streams are dilute.
- The density of the underflow stream is significantly greater than water.



Based on the schematic above write out all the possible Mass Balances that can be written for this system and simplify (i.e. group like terms together) the equations using the bulleted points above.

(c) additional space:

(d) (25 marks) Each resident of Chelsea, Quebec currently produces 350 L/d of wastewater. The current CSTR treatment basin that treats the wastewater has reached its capacity. The concentration of BOD entering the current CSTR wastewater treatment basin is 112 mg BOD/L and it is reduced to 25 mg BOD/L in the effluent stream. The volume of the treatment basin is 450 m^3 and the kinetic rate of removal is - 0.5 L/(mg BOD · d). The population of Chelsea is set to increase to 20,000 residents and the current CSTR system needs to be upgraded.

Knowing that PFRs can outperform CSTRs at certain kinetic orders, you realize that by removing the mixing mechanism of the current treatment basin and adding baffles to the basin you can convert the current treatment tank from a CSTR basin to a PFR basin (note the PFR will have the same volume as the current CSTR basin, V = 450 m^3).

In order to determine if the current basin can be converted to a PFR and achieve the same level of treatment (effluent BOD = 25 mg BOD/L), you will need to follow the following steps:

(i) derive the DESIGN EQUATION for the hydraulic retention time of a PFR basin using a mass balance approach that incorporates kinetics of removal. Your equation should be presented as HRT = …

(ii) use this design equation to calculate the FLOW RATE that the PFR basin can accommodate if the effluent BOD remains unchanged

(iii) verify if the flow rate for the PFR system is greater than the flow rate required to accommodate the 20,000 residential population.

(d) additional space: