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National Exams December 2015

04-Env-B3 – Contaminant Transport

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a CLOSED BOOK EXAM.
Any non-communicating calculator is permitted.
3. Four (4) problems constitute a complete exam paper.
The first four problems as they appear in the answer book will be marked.
4. Each problem is of equal value.
5. Note that the questions (a), (b), (c), (d) of each problem can be treated independently.
6. Most questions require an answer in essay format. Clarity and organization of the answer are important. Some of the questions require calculations please show all your steps.

Problem 1 (25 marks)

(a) Most physical transport in the environment occurs in the fluids that are air and water. There are primarily two kinds of physical processes by which chemicals are transported in fluids and into the environment. These are advection and diffusion.

(i) Explain in concise manner the meaning of these two types of transport processes and what differentiate them.

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(ii) Provide the mathematical equation(s) that describe each type of transport process.

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(b) The average settling velocity of a particle can be approximated by the Stokes equation , which applies to spherical particles as follow:

$$w_f = [(2/9)*g*((\rho_s/\rho_f) - 1)* r^2] / \eta_f$$

- w_f : Settling velocity
- G : Gravitational constant
- ρ_s : Density of spherical particle
- ρ_f : Density of the fluid
- r : Radius of the particle
- η_f : Kinematic viscosity of the fluid

If a stream of 3 m depth has an average velocity of 2 m/sec. This stream receives particles that are about 350 μm in diameter from a storm drain. Calculate the distance travel by the particles before settling to the river bottom.

Assumptions:

Particle density = 2600 kg / m³
 $\eta_f = 1.3 \cdot 10^{-2} \text{ cm}^2/\text{sec}$ at 10 °C

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Problem 2 (25 marks)

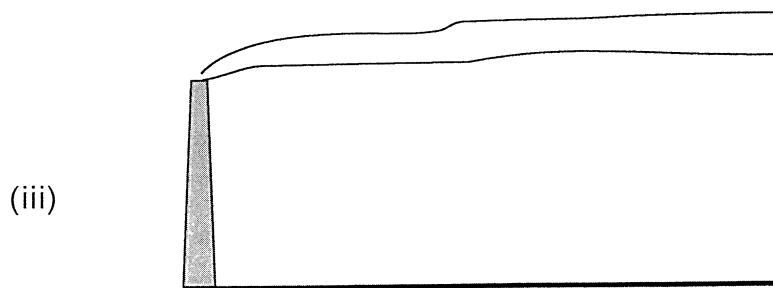
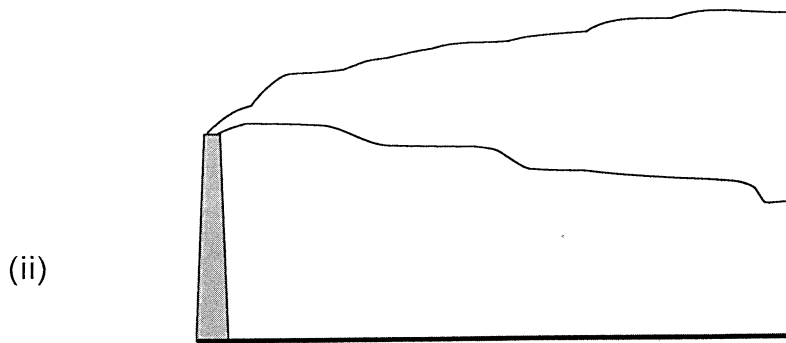
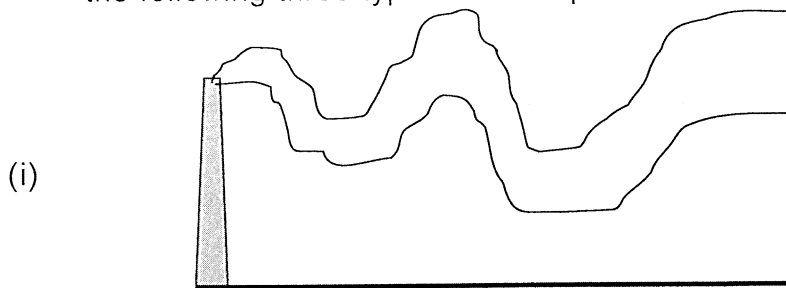
- (a) In the table below are reported the results of replicate sampling conducted at a waste water plant. Nine replicate tests are done and we can assume that there is little negligible bias in this testing.

Sample #	BOD (mg/L)
1	9.8
2	10.2
3	8.6
4	9.6
5	10.6
6	10.4
7	8.9
8	9.9
9	10.2

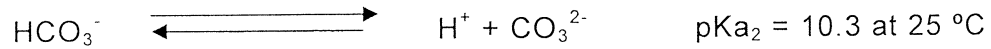
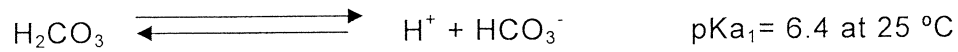
- (i) Explain in a very concise manner what is the meaning of BOD concentration and how it is measured?
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- (ii) Calculate the best estimate value for the BOD concentration base on the data in the table.
5
- (iii) What is the range in which one can be 95% confident that the true BOD mean occurs?
5
- (b) Explain in a concise manner what could be the impact of oxygen demanding wastes on rivers.
5
- (c) Explain in a concise manner the difference between primary and secondary air pollutants. Provide an example for each type.
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Problem 3 (25 marks)

- (a) Name and explain in a concise manner the mechanism of formation of the following three types of stack plumes:



- (b) Surface waters contain carbon dioxide dissolved in it. The carbon dioxide also reacts with water to form carbonate (HCO_3^- and CO_3^{2-}).



The predominant type of carbonate in water depends of its pH.

- 4 (i) Define in a concise manner, the meaning of “alkalinity” in water chemistry.
- 4 (ii) Show that at pH below 8.5, the alkalinity can be assumed to be predominantly due to HCO_3^- .
- 5 (iii) Calculate the concentration of CO_2 in water that has a pH of 7.6 and a total alkalinity of 320 mg/L as CaCO_3 .

Problem 4 (25 marks)

- 7 (a) Explain in a concise manner and by using a graphic, what is referred to as “MIXING HEIGHT” in atmospheric science and how it is estimated.
- 6 (b) A chemical may be removed from the atmosphere either by physical processes or by chemical transformation. Describe in a concise manner, three physical processes by which a contaminant may be removed from the atmosphere.

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(c) Two water wells (#1 and #2) are located 200 m apart in an unconfined sandy aquifer. Well #2 is directly down gradient of Well #1. The water head in the first well is 20 m and in the second well is 18 m. The hydraulic conductivity is estimated using a pump test as 10^{-3} cm/sec.

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- (i) Calculate the specific discharge between the two wells?
 - (ii) Calculate the rate at which non-sorbing chemicals dissolved in the groundwater move between wells if the aquifer porosity is about 0.3.

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Hint:

Darcy's Law: $q = -K * dh/dx$

Seepage velocity: $v = q/n$

Problem 5 (25 marks)

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- (a) Explain in a concise manner what is called "plume rise" in air pollution
- 3
- (b) What are the factors that have greatest impact on plume rise?
- 12
- (c) If the air quality standard for CO (based on an 8h measurement) is 9.0 ppm. Express this standard as a percentage by volume as well as in mg/m^3 at 1 atm and 25 °C.
- 6
- (d) Organic pollutant chemicals are susceptible to biodegradation in groundwater environment, just as they are in surface waters. Explain in a concise manner what is referred to as biodegradation.