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National Exams December 2013

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), (e), (f) or (g) 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) December 2013 – Env-B3

(a) Explain in a concise manner what could be the impact of oxygen demanding wastes on rivers.

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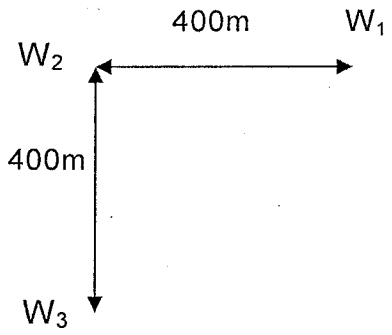
(b) Explain in a concise manner the difference between primary and secondary air pollutants. Provide an example for each type.

5

(a) Three wells (W_1, W_2 and W_3) form an equilateral triangle as shown in the schematic below. The total head for each of the three wells is: Well W_1: 9.6 m; Well W_2: 8.8 m; Well W_3: 8.0 m.



(i) Explain in a concise manner using a graphic what is the meaning of the hydraulic gradient, elevation head, the pressure head and total head for these three wells.

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(ii) Determine the direction of the flow

3

(iii) Calculate the hydraulic gradient with the data provided.

4

Problem 2 (25 marks)

(a) Hypochlorous acid is used as water disinfectant.

$$HOCl \rightleftharpoons H^+ + OCl^- \quad pK_a = 7.54$$

If 15 mg/L of hypochlorous acid is added to potable water at 25°C, for disinfection, and the final pH of the disinfected water is 7.0.

Calculate the percent of HOCl that has not been dissociated

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(b) Explain in a concise manner what is the meaning of BOD concentration and how it is measured?

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(c) Temperature was measured in an atmosphere at different elevations. For example, at a height of 4m, the atmosphere has a temperature of 20.2 °C and at an altitude of 224m the temperature of the atmosphere was 19.1 °C.

(i) Determine the existing lapse rate

5

(ii) Determine the stability of the atmosphere

5

Problem 3 (25 marks)

(a) Explain in a concise manner what is termed as inversion in atmospheric science and what are the different types of inversion?

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(b) A well-mixed sewage lagoon receives every day 430 m^3 of sewage from a drain pipe. This lagoon has a surface area of 10 hectares (or 100,000 m^2) and a depth of 1m.

This raw sewage discharging in the lagoon has a pollutant concentration of 180 mg/L. The organic matter in the sewage decays (biologically) in the lagoon following a first order kinetics. The rate constant for this decay is 0.70.

If we assume that there are no losses or gains of water in the lagoon at steady state, what would be the concentration of the pollutant in the lagoon effluent?

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(c) 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.

5

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

5

Problem 4 (25 marks) **December 2013 – Env-B3**

(a) Explain in a concise manner what is referred in atmospheric science as stability.

4

(b) Explain in a concise manner when is the atmosphere considered to be:

(i) Neutral

3

(ii) Stable

3

(iii) Unstable.

3

(c) The reaction between copper and hydroxide ions dissolved in water is represented by the following equation:

$$Cu^{2+} + OH^{-} \rightarrow CuOH^{+} \qquad \log K = 6.3$$

Calculate the ratio of Cu^{2+} to $CuOH^{+}$ ion in water if the hydroxide ion (OH^{-}) concentration is 10^{-4} mol/liter.

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Problem 5 (25 marks)

(a) An industrial power plant that burns high sulfur coal discharges its emissions through a cylindrical stack that is 150 m tall and has a diameter of 1.5 m. During combustion of this coal, sulfur dioxide is emitted through the stack at a rate of 1.5 kg/s; the flue gas temperature and exit velocity at the stack were respectively 315 °C and 10 m/s. At 3 km downwind on an overcast summer afternoon, calculate the centreline concentration of sulfur dioxide using the ***Equations provided below,*** if the wind speed at the top of the stack was 5 m/s and atmospheric pressure and temperature were respectively 95 kPa and 25 °C.

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(b) The oxides of nitrogen are one of the major concerns of air pollution.

(i) List three major sources of the oxides of nitrogen

3

(ii) Name three oxides of nitrogen that are present in sufficient quantities to contribute to air pollution

3

(iii) Provide two removal techniques for controlling the emission of oxides of nitrogen

4

Formulas for Problem 5

Holland

$$\Delta h = \frac{V_s\, d}{u}\left[1.5 + (2.68 \times 10^{-2}(P)(\frac{T_s - T_a}{T_s})\, d)\right]$$

V_s: Stack velocity in m/s
T_s: Stack temperature in K
T_a: air temperature in K
P: Pressure in kPa
d: Stack diameter in m
u: wind speed in m/s

D.B. Turner

$$GLC\,(x, y, 0, H) = \left(\frac{E}{\pi S_y S_z u}\right)\left(\exp\left(\frac{-1}{2}\left(\frac{y}{Sy}\right)^2\right)\right)\left(\exp\left(\frac{-1}{2}\left(\frac{H}{Sz}\right)^2\right)\right)$$

GLC (x, y, 0, H): Downwind concentration at ground level in g/m^3
E: Emission rate of pollutant in g/s
S_x, S_z: Plume standard deviation in m
U: Wind speed in m/s
x,y,z and H: Distances in m

D.O. Martin:

$S_x = a\ x^{0.894}$

$S_z = c\ x^d + f$

Stability class	x < 1 km				x ≥ 1 km		
	a	c	d	f	c	d	f
A	213	440.8	1.941	9.27	459.7	2.094	-9.6
B	156	100.6	1.149	3.3	108.2	1.098	2
C	104	61	0.911	0	61	0.911	0
D	68	33.2	0.725	-1.7	44.5	0.516	-13
E	50.5	22.8	0.678	1.3	55.4	0.305	-34
F	34	14.35	0.74	-0.35	62.6	0.18	-48.6

Source: D.O. Martin Journal of Air Pollution Control Association, vol. 26, pp. 145-146, 1976. Extracted from M.L. Davis & S.J. Masten, Principles of environmental Engineering and Science McGraw Hill, 2004