UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATION

April 17 2001

CHE460S - ENVIRONMENTAL PATHWAYS
AND
IMPACT ASSESSMENT

Exam Type A

Examiner - C. Q. Jia

Duration 2.5 hours; Permissible calculator: all non-programmable calculators; Attempt all questions which are not of equal value.

(20) 1. Define following terms

(a). fugacity capacity
(b). biomagnification factor
(c). sediment burial
(d). advection
(e). eutrophication
(f). geostrophic wind
(g). lapse rate
(h). transport half life
(i). growth dilution D value
(j). wet deposition

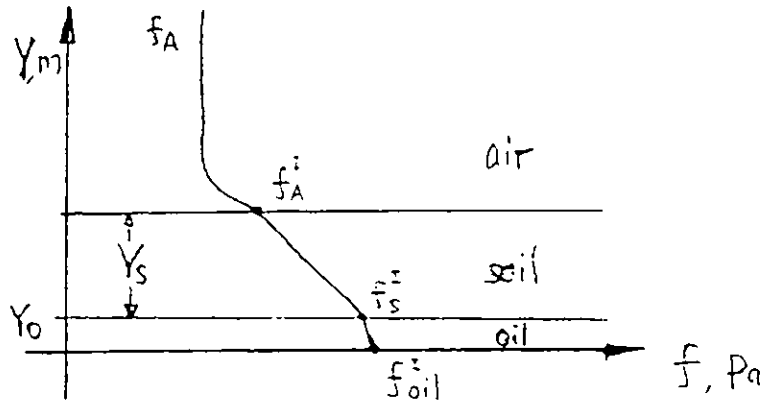
(30) 2. Qualitative analysis of fate of chemicals:

(a) There is a chemical source which is covered by a layer of oil. On the top of the oil layer there is a layer of soil. The fugacity profile is shown.

i) Derive an equation for quantifying the flux of volatilization of the chemical, with all the terms defined.

ii) Sketch the concentration profile of the chemical in the system.

iii) Discuss the effect of wind speed, temperature and water content in the soil on the rate of volatilization.



(b) A chemical is photo-oxidized in air by OH radical and O_3, simultaneously. Both reactions are 1st-order with respect to the oxidant and the chemical.

i) Derive an equation to calculate the D value for the overall photoxidation reaction. (Define all terms used)

ii) Identify two factors that may affect the rate of photochemical degradation of the chemical. (Explain briefly)

(c) In a well-mixed lake with upper and downstream rivers, there is a water-soluble non-volatile chemical, "A". Chemical A undergoes chemical reaction and produces a very volatile product "B".

i) Derive an equation for the overall D value of the removal of A and B from the lake.

ii) State all the assumptions made.

(20) 3. Answer the following questions:

(a). What are the most important degradation processes of organic chemicals in air, soil and ground water in general? Explain briefly.

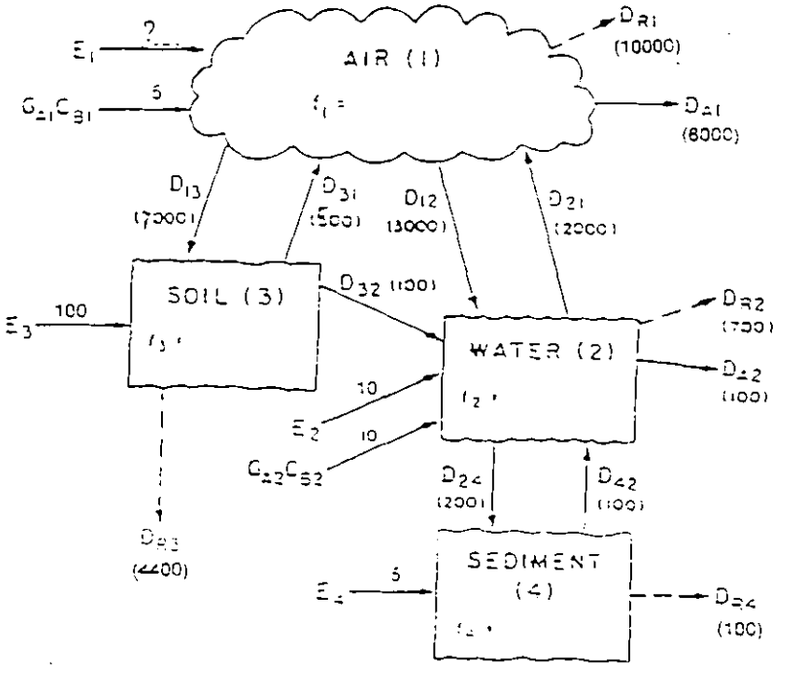
(b). There are three equations that can be used to calculate the fugacity capacity of a chemical in water. What are they? What are the conditions under which they can be applied?

(c) Why is fog often an indicator of high levels of pollutants in air? Why are foggy cities such as San Francisco often afflicted with air pollution problem?

(d). Using the phase (P-T) diagram for pure substance to define fugacity ratio. How does fugacity ratio vary with temperature? Which parameter(s) in Level II calculation will be affected by fugacity ratio.

(e). The NPRI report published by Environment Canada is essentially a database of chemical emissions to various media in Canada. If the total amount of various chemicals emitted by company "A" is greater than that by company "B", is it always justifiable to say "A is a worse polluter than B."? Explain.

(30) 4. Sketched below is a four-compartment environment under steady state. E_i (mol/h) and $G_{Ai}C_{Bi}$ (mol/h) are the direct emission and the inflow of a chemical to compartment "i", respectively. The rates of removal processes are given as D (mol/(h.Pa)) values, D_R for reaction, D_A for advection and D_{ij} for intermedia transport. All these values are known, except E_1, the direct emission to air.



Additional properties of the four media are

	Volume (m^3)	Z value ($mol/m^3.Pa$)
air:	$6x10^9$	$4x10^{-4}$
water:	$7x10^5$	0.1
soil:	$4.5x10^4$	12.3
sediment:	$2.1x10^4$	24.6

a). Given that there is no net transport between air and soil, write mass balance equations and determine the fugacity in air (f_1), water (f_2), soil (f_3) and sediment (f_4) as well as E_1. (10 points)

b). Calculate amounts, residence times of the chemical in four compartments, and the overall residence time of the chemical in the whole system. (5 points)

c). Determine the direction and rate (mol/h) of the net transport of the chemical between compartments. (5 points)

d). What are the relative contributions (%) of reaction, advection and intermedia transport to the removal of the chemical from air ? (5 points)

e). Does "no net transfer between air and soil" mean an equilibrium between air and soil? Explain (5 points)