**Name …….. Student I.D. ……**

**PRINCE OF SONGKLA UNIVERSITY**
**FACULTY OF ENGINEERING**

**Final Examination: Semester I** **Academic Year: 2003**
**Date: 3 October, 2003** **Time : 9:00 to 12:00 noon**
**Subject: 223-486; 835- 505 Hazardous Waste Management** **Room: A 401**

**Instructions:**

1. There are a total of seven (7) questions, **undergraduate students** must **answer any six (6)** questions. Total points = 300.
2. **Master's degree students** need to **do all the seven (7)** questions; Total points = 350.
3. Only dictionary and calculator are permitted for use during the examination.
4. All questions need to be answered **in English**.
5. Read all questions carefully and answer only what is required.

1. (15 points) a. What type of hazardous wastes can be treated by biological treatment processes?

(15 points) b. An in-situ aerobic biological treatment process for remediation of hydrocarbon spill from a leaky underground tank is being planned. The aquifer underneath ( about 5 m below the surface) has been contaminated with BTEX ( components of gasoline) compounds . What ingredients must be supplied to the site to start the in-situ biodegradation process?

( 20 points) c. Using a sketch to show one method of **delivery** of key ingredients to and **recovery** of end-products from the contaminated aquifer site to initiate in-situ biodegradation process.

2. ( 50 points) **Define or explain** the following:

a. Autotrophic microorganisms, also give an example

b. Explain how a Respirometer measures the aerobic biodegradability of a compound?

c. Explain Cometabolism? also give an example.

d. How is POHC chosen in a test burn of a Hazardous Waste ?

e. How does high organic content of soil affect its capacity to extract VOCs from it by Soil Vapor extraction process?

3. ( 50 points) Mark if the following statements are **True or False**

a. Henry's law constant indicates the partition between solid and liquid phases in a soil sample. ……. True……. False

b. Air sparging is a process of forcing the vaporization of volatile organic compounds from a contaminated aquifer to the vadose zone by blowing air into it. ….True……False

c. Soil vapor extraction process is quite effective with soils that are very dry, i.e. very low moisture content. ……True…..False.

d. One of the advantage of bioslurry reactor process to treat contaminated soil is that soils with high clay content can be treated successfully. …..True……False.

e. A packed bed reactor consists of a bed packed with media (stones or plastic materials) through which waste is passed. Biofilm containing microorganisms grows on the media causing the bio-oxidation of the waste ingredients. Such a treatment process is suitable for wastes containing high amounts of suspended solids. …….True……..False.

4. (40 points) a. A biotreatability study was conducted on a hazardous organic waste. It was found that the half-life for the organic compound in the waste under aerobic conditions was about 20 days at $25^{o}$ C. Determine how many days will it take to treat the waste from an initial concentration of 25 mg/L to a desired concentration of 2 mg/L. Assume that the waste biodegradation follows first order kinetics.
( $dS/dt = -kS$; $\ln S_o - \ln S = kt$; $t_{1/2} = 0.693/k$).

(10 points) b. If the temperature in the field drops to $10^{o}$ C and the reaction rate constant k reduces by 50% in the system described in 4 a. above , what % removal of the organic compound will be obtained after 100 days of biodegradation treatment of the waste?

5.(50 points) A waste solvent is to be incinerated. The combustion reaction for the solvent is as follows:

$$2\ C_8\ H_{10} + 21\ O_2 + 80.325\ N_2 = 16\ CO_2 + 10\ H_2O + 80.325\ N_2\ ;$$

[Given : Molecular weight : $N_2 = 28$; $C = 12$; $O_2 = 32$ ; $H=1$]
Determine the amount of air needed and the amount of $CO_2$ produced, both in kg per kg of solvent combusted.

6. (15 points) a. Name the steps involved to start a "Pump and Treat" option for cleaning a contaminated aquifer. ( mention key words only)
   (15 points) b. What are the limitations of the "Pump and Treat" technology for cleaning a contaminated aquifer? (mention key words only)
   (10 points) c. Name two compounds in a contaminated aquifer that can be treated by zero valent iron ( $Fe^{o}$ ) reactive barrier process .
   (10 points) d. Name another type of in-situ reactive barrier process that can be used to treat contaminated aquifer?

7. (25 points) a. Sketch a cross section of a hazardous waste landfill with a leachate collection system. Do show the liner system also.

(15 points) b. What type of post-closure monitoring is needed for a hazardous waste landfill?

(10 points) c. What would be a recommended process to treat landfill leachate containing soluble heavy metals?