

National Examination, December 2004

**98-Env-B5 Solid and Hazardous Waste Management**

3 hours duration

**NOTES:**

1. The total possible examination mark is 100.
2. This examination is an **OPEN BOOK EXAM**. Books and notes are allowed. Any calculators are permitted.
3. 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.

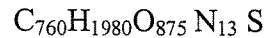
## 98-Env-B5 Solid and Hazardous Waste Management

10 points

1. Define or describe briefly each of the following terms:
  - 1.1 Turbulence factor in combustion processes
  - 1.2 At-site time
  - 1.3 Compost
  - 1.4 Hazardous waste
  - 1.5 Moisture content
  - 1.6 Integrated solid waste management
  - 1.7 Pyrolysis
  - 1.8 Three Ts in incineration
  - 1.9 Vadose zone
  - 1.10 Anaerobic digestion

5 points

2. The chemical composition of a typical residential MSW was determined to be:



Determine the energy content of this waste.

7 points

3. Determine the time required for the concentrations of toluene and Dieldrin spilled in a shallow leachate treatment pond to be reduced to one quarter of their initial values.

Assume first-order removal constants for toluene and Dieldrin are 0.0665/hr and  $2.665 \times 10^{-5}$ /hr, respectively.

3 points

4. State 3 methods commonly used to estimate waste quantities.

7 points

5. In your first position as junior city engineer you are assigned to report on the generation rates and composition of solid wastes for various sources of your community.

5.1 How would you go about it?

5.2 If these data were needed in 30 days and thus you had no time to assess seasonal effects, how would you estimate this factor?

**32 points sub-total**

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10 points

6. As a consulting engineer, you have been commissioned to develop a comprehensive solid waste system for a community interested in achieving a greater recovery and reuse of its solid wastes. Two of the possible alternatives are separation at home or separation at a materials recovery facility. What important factors must be considered in evaluating these two alternatives?

15 points

7. The household waste generation rates given below were observed over a period of time on a typical collection route. Assuming that curbside density of the waste is  $120 \text{ kg/m}^3$ , estimate the percentage of the time a  $24 \text{ m}^3$  collection truck with a compaction ratio of 2.5 will need more than one trip to service 82 households. The observed waste generation rates are 42, 60, 35, 27, 50, 94, 72 kg/household.week.

10 points

8. Develop a process flow diagram to process source separated mixed paper and mixed recyclables composed of plastics, glass, tin cans, and aluminum cans.

6 points

9. Estimate the theoretical amount of gas (methane and carbon dioxide) that could be produced under anaerobic conditions from wastes with the following chemical composition:
- 9.1  $\text{C}_{12}\text{H}_{22}\text{O}_{11}$  (sucrose)
  - 9.2  $\text{C}_2\text{H}_5\text{O}_2\text{N}$  (glycine)
  - 9.3  $\text{C}_{60}\text{H}_{96}\text{O}_{38}\text{N}$

7 points

10. Determine the breakthrough time in years for leachate to penetrate a 4 ft thick clay liner. Assume the effective porosity is 0.20, the coefficient of permeability is  $10^{-7} \text{ cm/s}$ , and the hydraulic head is 5.5 ft.

5 points

11. If an air velocity of 2,000 ft/min is to be used to transport finely ground material with a specific gravity of 0.75 in a horizontal duct, estimate the maximum particle size that can be transported.

**53 points sub-total**

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15 points

12. The sludge from a wastewater treatment plant serving 500,000 persons is currently disposed of in a sanitary landfill. Because the capacity of the existing landfill will soon be exhausted it has been proposed to combust the treatment plant sludge using processed MSW as a fuel source.

Two alternative modes of operation are to be evaluated:

In the first, treatment plant sludge with a fuel value of 7,500 BTU/lb (based on dry solids) and a solids content of 5 percent, are to be mixed with processed MSW (5,065 BTU/lb) and combusted.

In the second alternative, dewatered sludge with a solids content of 20 percent and a fuel value of 6,500 BTU/lb (based on dry solids) is to be mixed with the processed MSW before being combusted. It should be noted that the fuel value of the dewatered solids is lower because of the chemicals added as an aid to dewatering.

Assuming that the specific gravity of the combined dry sludge with or without the addition of chemicals is 1.10, the per capita sludge production on a dry basis is 0.35 lb/day, and the moisture content of the processed MSW is 20 percent, **determine** the amount of MSW that must be added to the treatment plant sludge for both alternatives to achieve a final moisture content of 60 percent.

Would the required quantities of processed MSW be available in the wastes from the community?

State clearly all your assumptions.

**15 points sub-total**

**TOTAL 100 points**