

National Examination, December 2011

04-Env-A6 – Solid Waste Engineering and Management

3 hours duration

NOTES:

1. The total possible examination mark is **100**.
2. This examination is an **OPEN BOOK EXAM**.
3. A Casio or Sharp approved calculator is permitted.
4. *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.*
5. All **11** questions constitute a complete paper.

04-Env-A6 – Solid Waste Engineering and Management

- 2 1. Darcy's law is expressed as: $Q = -KAh/dL$
Why a minus sign?
- 10 2. A sanitary landfill is set in clay having porosity of 50% and if $K = 1 \times 10^{-7}$ cm/s.
Darcy's Law: $Q = -KSA$
where; Q = quantity of liquid flowing through area A per unit of time = nvA
 K = coefficient of hydraulic conductivity (dependent on soil type)
 S = hydraulic gradient i.e. the change in elevation of the "free" water surface between the two points being considered divided by the distance through which the liquid must travel.
 A = gross cross-sectional area through which the flow passes
 v = velocity at which the liquid travels through the soil
 n = soil porosity i.e. void volume divided by total volume of the soil mass
- 2.1 How long would it take the leachate to percolate from the bottom of the landfill through the underlying soil to the groundwater table 1.5 m below (assuming that the leachate is not allowed to build up in the landfill and the underlying soil is saturated,
- 2.2 How long would it take if the soil had a hydraulic conductivity of 1×10^{-8} cm/s?
- 2.3 If the sanitary landfill became filled to overflowing what effect would this have on the liquid time of travel determined in parts (2.1) and (2.2)?
- 7 3. Name 7 factors that influence the composition of municipal solid waste.
- 10 4. A mass burning incinerator with heat recovery operates on 400 t/d of municipal solid waste with natural gas as a supplementary fuel. A plan for residential source separation is expected to reduce the amount of paper and cardboard collected by 20%. For the incinerator to maintain steam production, the heating value of the lost combustibles will have to be replaced by natural gas at an average cost of \$0.50/m³. Neglecting changes in collecting costs, what price per tonne would need to be received for the paper for the municipality to break even?
- 6 5. List some of the major problems with landfilling.
- 7 6. The solid wastes from a summer camp with 100 children and a staff of 25 are to be collected once per week. If bottles and cans (representing 20% of the weight) are removed, paper wastes (40%) are burned in the camp incinerator, and only the wastes from the kitchen (30%) and miscellaneous wastes from the cabins (10%) are collected, what volume will be picked up?

04-Env-A6 – Solid Waste Engineering and Management

- 10 7. List the essential elements you would use in a Life Cycle Analysis of a solid waste management plan. State all of your assumptions.
- 20 8. The town of Dentalfloss is landfilling their municipal solid waste (MSW). The landfill only has enough remaining capacity to handle their MSW for another 3 years. Composting is one option to extend the landfill life. You have been commissioned to prepare a feasibility report about whether or not composting their municipal solid waste is represents a viable solution. Prepare a *report index* showing major- and associated sub-headings of all factors that you consider to be important for this assignment.
- 15 9. Develop a *design* and an *operational* plan for landfill.
- 6 10. A residential area of 40 ha contains 300 single-family residences and 8 ha with multiple-family units housing 400 people. With two curb-side pick-ups per week, how many trips on each collection day would one packer truck (4 tonne capacity) need to make in order to serve this area? Assume 4 residents/single family unit.
- 7 11. Over a three year period, wastes from a population of 100,000 have been placed in a sanitary landfill with a gas recovery system. This practice is to continue into the foreseeable future, so a steady supply of gas with 55% methane (CH₄) is expected. A nearby year-round work camp has 50 oil-heated detached homes for their personnel. The homes use an average of 100×10^6 kJ of heat energy during the year and have a peak demand during the coldest month of 2.5 times the average. Will there be enough landfill gas available to heat these homes? *Make and state all your assumptions.*

100 total mark