

National Examination May 2013

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 **CLOSED BOOK EXAM**.
3. Candidates are permitted **ONE** (1) letter sized aid sheet (8.5 "x 11") both sides.
4. One of two calculators is permitted, any Casio or Sharp approved models.
5. *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.*
6. All **17** questions constitute a complete paper.

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- 3 1. Based on typical energy contents of the components of municipal solid waste as collected, determine the energy content in refuse consisting of 50% and 20% metal, glass, and ash with the balance being food and other organic wastes.

Material	Typical Energy Content kJ/kg
combustibles	23,200
paper	16,300
refuse	10,500
organic wastes	5,800

- 3 2. Aside from economic considerations in solid waste management name 3 other considerations.
- 4 3. Waste collection costs are typically 80% of solid waste budgets. What are 4 other possible factors in solid waste management strategies that should be considered in effort to reduce costs?
- 3 4. What are some of the disposal options of solid waste?
- 3 5. Name 3 problems with Landfilling.
- 2 6. Name 2 of the most important considerations in the generation of Leachate.
- 4 7. What are the factors that influence gas production in a Landfill?
- 3 8. Explain the meaning of integrated waste management.
- 4 9. Name and describe 2 leachate treatment and disposal options.
- 7 10. As the city of Troys' engineer responsible for solid waste management you are examining possible and feasible solutions to the city's solid waste management challenges and opportunities. You have identified a number of solutions, but now need to undertake a life-cycle analysis of the various solutions. Identify and outline the steps you would take in a life-cycle analysis of a composting solution.

36 *sub-total*

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5 11. Define:

- 11.1 Solid wastes
- 11.2 Solid municipal waste
- 11.3 Pyrolysis
- 11.4 Wet oxidation
- 11.5 Darcy's Law

27 12. Name:

- 4 12.1 - 4 solid waste conversion processes.
- 3 12.2 - 3 factors in the design of a solid waste collection system.
- 3 12.3 - 3 important criteria in the design of a composting operation.
- 4 12.4 - 4 basic considerations in designing a landfill.
- 4 12.5 - 4 problems associated with land filling of municipal solid waste.
- 3 12.6 - 3 factors to consider in leachate control from a landfill.
- 3 12.7 - 3 different leachate treatment processes
- 3 12.8 - 3 variables that govern landfill gas production.

8 13. 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 (CH_4) is expected. A nearby mining operation has 50 oil-heated detached homes for married 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.***

6 14. A landfill has a compacted density of 600 kg/m^3 , a refuse depth of 9 m, a moisture content of 20% by volume, and a 1 m thick clay cover with a 2% slope. Estimate:
14.1 the quantity of leachate that would be generated each year
14.2 how long it will be before each year's deposit of refuse is saturated and leachate flows from that section.

Make and state your assumptions about rainfall and evapo-transpiration values.

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- 7 15. You completed an analysis of a municipal solid waste and summarized its' composition in Table 1. Estimate the moisture content and density of this municipal solid waste.

TABLE 1 SOLID WASTE ANALYSIS

COMPONENTS	Sample 100 kg	VALUES ESTIMATED				
		<i>moisture*</i>		dry solids		<i>density*</i>
	kg	%	kg	%	kg	kg/m ³
Paper	45	7	3.2	93	41.9	80
Organics	20	70	14.0	30	6.0	300
Metal (Fe)	7	3	0.2	97	6.8	480
Glass	10	2	0.2	98	9.8	160
Ashes	3	8	0.2	92	2.8	480
Miscellaneous	15	20	3.0	80	12.0	160
SOLID WASTE	100					

* from Reference

- 5 16. 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.

**TABLE 2 URBAN SOLID WASTE GENERATION
IN NORTH AMERICA**

SOLID WASTE SOURCE	kg/capita/day
Residential	1.1
Commercial	0.9
Special*	0.9
Total MUNICIPAL	2.9
Industrial	1.4
Total MUNICIPAL + INDUSTRIAL	4.3

* construction debris, leaves, street litter
& large discards

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- 6 17. 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 \$0.40/m³. Neglecting changes in collection costs, what price per tonne would need to be received for the paper for the municipality to break even?

Neglect the higher efficiency of incineration of natural gas compared to refuse.
(Energy content of paper = 16,300 kJ/kg; energy content of natural gas = 37,300 kJ/m³). *Make and state any assumptions.*

100 TOTAL