UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2015

Module Number: CE 5254 **Module Name: Integrated solid waste management**

[Three Hours]

[Answer **all 5 questions**, each question carries 12 marks]

Q1. As an alternative, Municipal Solid Waste (MSW) can directly be combusted in waste-to-energy facilities to generate electricity. The combustibility depends on several chemical properties of the solid waste.

a) Describe briefly the 'proximate analyses' of MSW.

[2 Marks]

b) Table Q1 shows the energy content of each component of a 50 *kg* MSW sample, which was obtained by the bomb calorimeter experiment.

i) Determine the 'as - discarded' energy content for this MSW sample.

[5 Marks]

ii) What will be the energy content on 'dry basis', if the moisture content is 28%?

[2 Marks]

iii) This municipality has implemented a new reuse/recycle program among the house holders. Estimate the 'as-discarded' energy content of the total MSW generated within the municipality, excluding 70% of the paper and 80% of the cardboard, which are separated for reuse/recycle by the house holders.

[3 Marks]

Table Q1: Energy contents of the components of a 50 *kg* MSW sample.

Component	Mass (*kg*)	Energy (*kJ/kg*)
Food wastes	5	4650
Paper	20	16750
Cardboard	9	16280
Plastics	4	32560
Textiles	1.2	17440
Rubber	0.4	23260
Leather	0.2	17310
Yard wastes	5.2	6510
Wood	2	18620
Glass	3	140

Q2. a) 'Field capacity' is a useful physical property of the municipal solid waste (MSW). Describe briefly the 'field capacity' and its importance for the MSW management.

[2 Marks]

b) Typical 'ultimate analysis' data of the combustible components of MSW are shown in Table Q2 (a). Table Q2 (b) shows the typical composition of a 50 *kg* MSW sample.

i) Estimate the 'as-discarded' overall moisture content of this MSW sample.

[3 Marks]

ii) Determine the chemical formula of this solid waste sample for the following conditions: 'without water' and 'with water'

[3 +4 Marks]

Table Q2 (a): Typical 'ultimate analysis' data of the combustible components of MSW.

Component	Percent by weight (dry basis)					
	C	H	O	N	S	Ash
Food wastes	48.0	6.4	37.6	2.6	0.4	5.0
Paper	43.5	6.0	44.0	0.3	0.2	6.0
Cardboard	44.0	5.9	44.6	0.3	0.2	5.0
Plastics	60.0	7.2	22.8	-	-	10.0
Textiles	55.0	6.6	31.2	4.6	0.15	2.5
Rubber	78.0	10.0	-	2.0	-	10.0
Leather	60.0	8.0	11.6	10.0	0.4	10.0
Yard wastes	47.8	6.0	38.0	3.4	0.3	4.5
Wood	49.5	6.0	42.7	0.2	0.1	1.5

Table Q2 (b): Typical composition of a 50 *kg* MSW sample.

Component	Percent by weight (%)	Typical moisture content (% weight)
Food wastes	12	70
Paper	41	6
Cardboard	9	5
Plastics	8	2
Textiles	3	10
Rubber	2.5	2
Leather	1.5	10
Yard wastes	18.5	60
Wood	4.5	20

Q3. The 'integrated solid waste management hierarchy' is a concept for the waste management, and it acts as a base for developing various waste management strategies.

a) Draw the 'integrated solid waste management hierarchy'.

[2 Marks]

b) The current practice of solid waste management at a campus premises is to collect waste as 'mixed waste' and dispose them on open dumps followed by

open burning. Develop a sustainable solid waste management plan based on the 'integrated solid waste management hierarchy' in order to handle the solid waste safely and effectively with least adverse impacts on the human health and environment.

[7 Marks]

c) Collection includes not only the gathering or picking up of solid waste from various sources but also the hauling to the location where the contents of the collection vehicles are emptied. Hauled Container System (HCS) and Stationary Container System (SCS) are two common types of collection systems. Using simple sketches, explain briefly the two systems. Discuss the advantages and disadvantages of HSC and SCS.

[3 Marks]

Q4. a) Draw a diagram of a sanitary landfill with all essential components and name them.

[3 Marks]

b) The available capacity of a sanitary landfill in a city is 500,000 m^3. Calculate the time period it can be used if the waste generation characteristics of the city are as in Table Q4. State any assumptions.

[4 Marks]

Table Q4: Waste generation in the city.

Year	End of year population (× 1000)	Waste quantity (m^3/ *capita. d*)
2013	12	0.02
2014	13	0.02
2015	15	0.019
2016	17	0.019
2017	19	0.019
2018	20	0.019
2019	21	0.017
2020	22	0.017

c) Describe the stages of the solid waste decomposition process in a landfill.

[2 Marks]

d) Describe how the environmental pollution caused by a sanitary landfill is minimized.

[3 Marks]

Q5. a) Describe the practical issues, which make the stoichiometric air combustion practically difficult.

[2 Marks]

b) 'Pyrolisis' is a thermal conversion method in which several outputs are produced. Discuss the characteristics of 'pyrolisis' in terms of the air supply and outputs produced.

[3 Marks]

c) Determine the volume reduction of the solid waste sample, characteristics of which are indicated in Table Q5, after combustion. Assume that the specific weight of the residue is 500 kg/m^3 and the average specific weight of the waste is 150 kg/m^3.

Table Q5: Characteristics of waste.

Type	Percentage composition	Inert residue %
Food waste	45	5
Plastic	25	3
Polythene	15	2
Yard waste	10	5
Tin cans	5	40

[4 Marks]

d) Analyze the positive and negative aspects of composting facilities operated by the local authorities in Galle district.

[3 Marks]