UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
MAY 2024 SEMESTER

COURSE : **CEB4243 - WASTE MANAGEMENT & UTILIZATION**

DATE : **5 AUGUST 2024 (MONDAY)**

TIME : **2.30 PM - 5.30 PM (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.

2. Begin **EACH** answer on a new page in the Answer Booklet.

3. Indicate clearly answers that are cancelled, if any.

4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.

5. **DO NOT** open this Question Booklet until instructed.

Note :

   i. There are **SEVEN (7)** pages in this Question Booklet including the cover page .

   ii. **DOUBLE-SIDED** Question Booklet.

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1. Despite globalization and interconnected food systems, various regions worldwide experienced significant food loss and waste at different stages of the food supply chain. **FIGURE Q1** shows the percentage of food loss and waste by region and stage, highlighting discrepancies between developed and developing regions. Given the global commitment to Sustainable Development Goal 12 (SDG12): Responsible consumption and production, it is crucial to identify and implement effective initiatives to reduce food loss and waste in both regions.
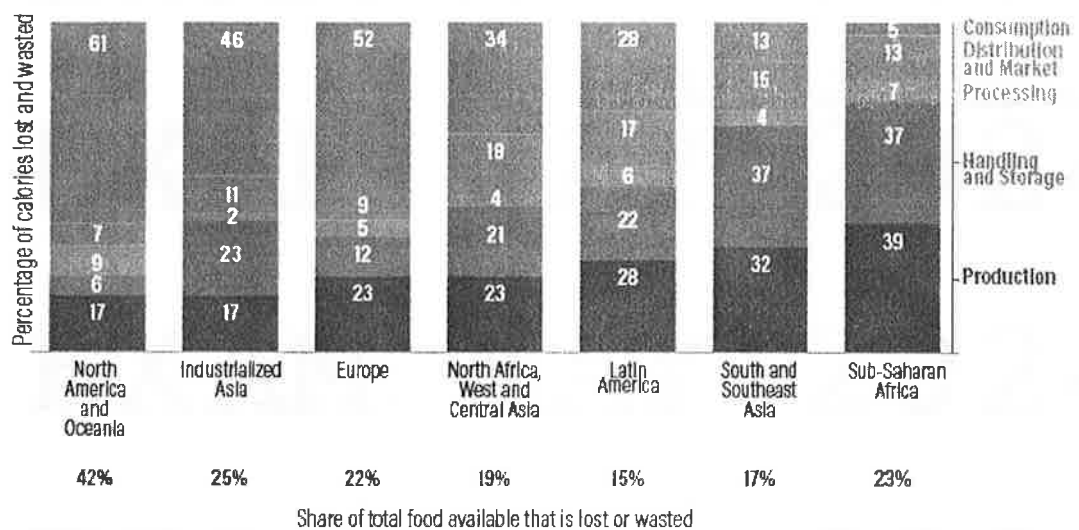

FIGURE Q1: Food loss and waste by region and stage

a. Justify the key differences in food loss and waste at different stages of the food supply chain between developed regions and developing regions.

[6 marks]

b. Suggest **THREE (3)** initiatives under SDG12 that could address these differences and effectively reduce food loss and waste in both types of regions.

[9 marks]

c. Propose a strategic framework of solid waste management to support SDG12, with appropriate examples. Justify your proposal.

[10 marks]

2. Harbor City Council (HCC) aims to evaluate the potential solid waste management methods to cater the municipal solid waste (MSW) generated by an emerging township with a projected population of 480 capita/km². The projected township land expansion is estimated to be 70 km². The HCC's recent campaign survey shows that the daily average MSW generation is 1.20 kg/capita.day, with compositional breakdown outlined in **TABLE Q2a**. An ultimate analysis was conducted for a 100 kg of the MSW sample to determine the elemental proportions of the waste. **TABLE Q2b** shows the dry basis organic chemical components obtained from the analysis.

TABLE Q2a: Compositional breakdown of MSW

Component	Percent by mass	Density (kg/m³)	Moisture content (%)	Energy (kJ/kg)
Food waste	45.0	300	70	4500
Paper	15.0	80	8	16000
Plastics	12.0	70	5	32000
Glass	5.0	200	3	0
Aluminium	8.0	150	2	0
Textile	10.0	90	12	28000
Ash	5.0	1100	3	7000

TABLE Q2b: Organic chemical component of MSW

Component	Chemical Component (kg) (dry basis)				
	C	H	O	N	S
Food waste	7.500	1.800	6.200	0.400	0.060
Paper	4.800	0.500	3.900	0.030	0.020
Plastics	8.500	0.900	3.000	0.000	0.000
Textile	5.000	0.600	2.800	0.500	0.010

a. Research conducted by HCC suggested that thermal conversion is suitable for treating waste with a moisture content below 40%. Assess the feasibility of using this type of conversion to treat the MSW from the township.

[6 marks]

b. Evaluate the effect of moisture and ash content towards the energy content of the MSW. Support your evaluation with appropriate calculations and justifications.

[8 marks]

c. Derive an approximate molecular formula for the organic portion of the MSW.

[11 marks]

3. **FIGURE Q3** depicts a moving grate incineration plant proposed to burn an amount of solid waste. To ensure complete combustion during the incineration of the waste, a total of 14,000 m³ of air was supplied to the process. The composition of the waste is detailed in **TABLE Q3**.
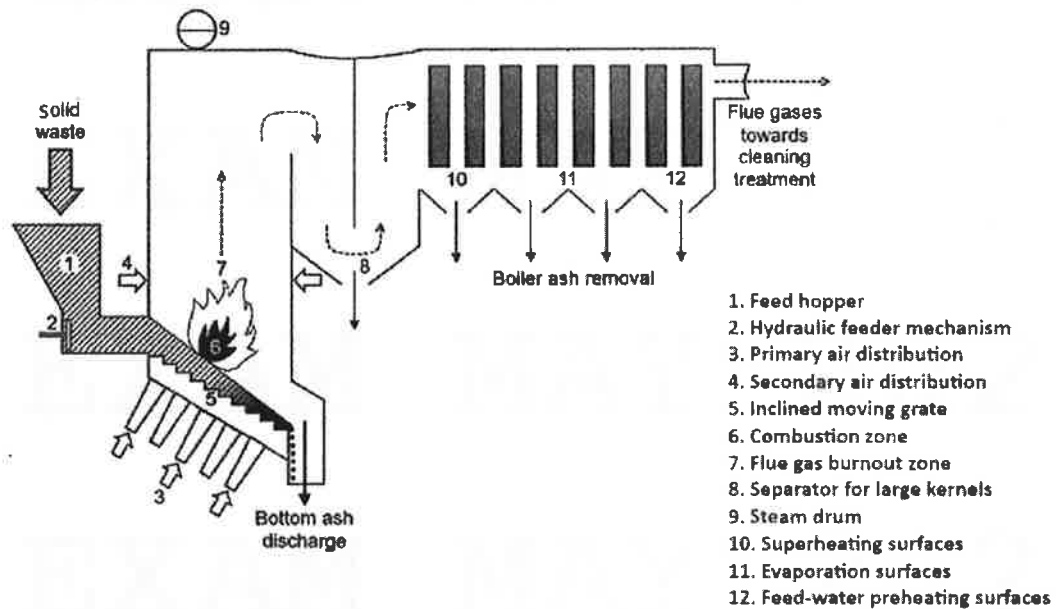

1. Feed hopper
2. Hydraulic feeder mechanism
3. Primary air distribution
4. Secondary air distribution
5. Inclined moving grate
6. Combustion zone
7. Flue gas burnout zone
8. Separator for large kernels
9. Steam drum
10. Superheating surfaces
11. Evaporation surfaces
12. Feed-water preheating surfaces

FIGURE Q3: Incineration plant

TABLE Q3: Composition of solid waste for incineration

Component	Mass (kg)	Moisture Content (%)	Inert Residue (%)
Food waste	290	70	5
Paper	340	6	6
Cardboard	60	5	5
Plastic	70	2	10
Textile	20	10	6.5
Rubber	5	2	9.9
Leather	5	10	9.0
Yard waste	185	60	4.5
Wood	20	20	1.5
Glass	80	2	98
Tin cans	60	3	98
Aluminum	5	2	96
Other metals	30	3	98
Dirt, ash, etc	30	8	68

a. Elaborate the combustion process that happens in the moving grate incinerator.

[10 marks]

b. Prove that the combustion of the solid waste by the incineration plant is complete. Assume that the composition of the organic waste is given by C_7H_{16}, and the specific weight of the air is 1.2 kg/m^3.

[8 marks]

c. The incineration process is considered efficient if it reduces the volume of solid waste by at least 92%. Evaluate the efficiency of the incineration plant, assuming the average specific weight of the solid waste in the combustor storage pit and its residue is 350 kg/m^3 and 600 kg/m^3, respectively.

[7 marks]

4. EcoBloom Landscaping is designing an appropriate composting system for the biological conversion of food and yard waste collected from three nearby residential areas. The conversion process has several targets, including a 4-week production time, minimal odour production, reduction of pathogens to safe levels, and material recovery with minimal nutrient loss. **TABLE Q4** shows the carbon to nitrogen (C/N) ratio of the waste mixture.

TABLE Q4: C/N ratio of waste mixture

Residential Area	C/N Ratio
Greenfield Heights	30 – 45
Maplewood Estates	10 – 20
Sunset Grove	25 – 50

a. As part of the design team, propose the composting system needed for the above biological conversion. Support your proposal with an appropriate sketch and explanation of the process involved.

[7 marks]

b. Analyze the importance of **FOUR (4)** design parameters in implementing the biological conversion through the proposed equipment in **part (a)**.

[8 marks]

c. Based on the given data in **TABLE Q4**, assess the suitability of the waste mixture from the three residential areas for composting. Justify your decision with appropriate predictions on the biodegradation rate, quality of the compost, and other relevant details related to the composting process. Additionally, propose a suitable method to enhance the biodegradation rate of any of the waste, if necessary.

[10 marks]

- END OF PAPER -