



KENYATTA UNIVERSITY

**EXAMINATION FOR THE DEGREE OF MASTER OF SCIENCE (RENEWABLE
ENERGY TECHNOLOGY)**

SET 810: BIOMAS CONVERSION

2ND SEMESTER 2021/2022

TIME: 3 HOURS

**INSTRUCTIONS: ANSWER QUESTION ONE (COMPULSORY) AND ANY OTHER
TWO QUESTIONS.**

Question One [30 Marks]

- a) i. Define the term *biomass* and describe its composition (2 ½ mark)
ii. Describe three challenges associated with the use of biomass as an energy source (3 marks)
- b) Briefly describe what preparation of raw material during biogas production entails (4 marks)
- c) What are the limitations of the Low-Rate Biogas Digesters to which their slowness can be attributed? (3 marks)
- d) Table 1 below shows typical manure output from farm animals.

Table 1

Animal	Total wet manure per animal per day(kg)	Total solids per kg	Moisture mass content per wet mass (%)
Dairy cow (~500kg)	35	4.5	87
Beef steer (~300kg)	25	3.2	87
Fattening pig (~60kg)	3.3	0.3	91
Laying hen	0.12	0.03	75

Calculate

- i. the volume of a biogas digester suitable for the output of 6000 pigs
- ii. the power available from the digester, assuming a retention time of 20 days, and a burner efficiency of 0.6. (3 ½ marks)
- e) List two advantages and one disadvantage of the utilization of ethanol as a fuel. (3 marks)
- f) Draw labelled sketches of a small scale pyrolysis unit (4 marks)
- g) Draw a flow chart that summarises the briquetting process. (3 marks)
- h) List two requirements of downstream processes in ash pre-treatment and utilization used to ensure the farmer is supplied with a useful product (2 marks)
- i) List four of the elements which constitute a gasification process system (2 marks)

Question Two [20 Marks]

- a) i. List and describe three cellulosic feedstocks which can be considered for biofuels, giving two examples in each case (3 marks)

- ii. Name and describe the main components of cellulosic biomass (8 ½ marks)
- b) Distinguish between the following terms: *higher heating value* (HHV) and *lower heating value* (LHV) (2 marks)
- c) One of the factors that influences anaerobic digestion is C/N ratio. Discuss this term under the following sub-headings: Meaning of term, optimum range for anaerobic digestion, effect of high C/N ratio, effect of low C/N ratio, average C/N ratios in common substrates, how to maintain optimum C/N ratios (3 marks)
- d) Name the first stage of anaerobic digestion and discuss the stage under the following sub-headings: meaning of the term, primary feedstock, bacteria (their action, categories and products) (3 ½ marks)

Question Three [20 Marks]

- a) Biodigesters can be classified into two: low rate and high rate biodigesters
 - i. What are the general differences between low rate and high rate bio digesters, other than the time they require to produce biogas? (4 marks)
 - ii. Name and describe four features of low rate biodigesters (4 marks)
 - iii. Draw a labelled diagram of a Chinese dome digester for small scale use. (4 marks)
- b) i. Two energy-demanding separation steps are necessary to obtain purified ethanol (95.63% by mass) from binary azeotrope ethanol-water. Describe the two steps. (3 marks)
- ii. List five environmental issues connected with ethanol production (5 marks)

Question Four [20 Marks]

- a) i. Define the term *biomass pyrolysis* (1 mark)
- ii. List the products of pyrolysis and explain the factors on which their relative proportions depend (3 marks)
- iii. The pyrolysis process takes place in a series of stages in a sequential manner. Discuss these processes as they occur at low heating rate. (8 marks)
- iv. Draw a labelled diagram of a *bubbling fluidized bed pyrolyzer* (4 marks)
- b) i. What do you understand by the terms *briquetting* and *briquette*? (1 mark)

- ii. Describe the operation of a mechanical piston press when used as an agglomeration machine during the production of briquettes. (3 marks)

Question Five [20 Marks]

- a) Treatment of biomass ash is done by influencing composition and characteristics of the ash, the biomass ash treatment technologies being combustion technology and downstream processes (ash pre-treatment and utilization).
- i. List the primary and secondary measures which constitute combustion technology for biomass ash. (3 marks)
- ii. Use a table to show the logistics of a smooth-running closed-cycle economy for biomass ash. (3 marks)
- iii. List four ways in which biomass ash disposal can be accomplished (2 marks)
- b) Describe five significant features of pressurized as well as three significant features of atmospheric gasifiers? (12 marks)