



KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

**SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF
SCIENCE (ENERGY ENGINEERING)**

SET 437: BIOMASS THERMOCHEMICAL CONVERSION TECHNOLOGY

DATE: FRIDAY, 13TH APRIL 2012

TIME: 8.00 A.M. – 10.00 A.M.

INSTRUCTIONS

- **There are FIVE questions in this paper.**
All questions carry equal marks.
- **Answer ANY THREE questions.**

QUESTION ONE

CHARCOAL, a high-grade solid biofuel, is made/produced by carbonization of appropriate biomass materials.

- (a) Describe, in details, the physical and chemical changes/transformations that take place during the charcoal production process from wood by pyrolysis in a KILN.
- (12 marks)
- (b) Describe, in details, the influence/effects of the following factors on the pyrolysis products.

- (i) Temperature
- (ii) Heating rate

Show a graphical illustration of the products variation with temperature, i.e., temperature Vs. products.

(8 marks)

QUESTION TWO

Producer gas; the gaseous fuel for biomass gasification, is composed of several specific gases and non-gaseous components.

- (a) (i) Name all the gaseous components of producer gas (in case of air-gasification) (4 marks)
- (ii) Show all the combustible, and non-combustible gas components. (4 marks)
- (b) The final product gas composition will depend on some factors, and the gaseous fuel can be used in two principal ways.
Name all the factors that determine the producer gas composition; and its potential utilizations. Each should be clear. (5 marks)
- (c) Name the two non-gaseous impurities in producer gas, and outline the negative effects of each.
One of the impurities is of major concern in producer gas. Name it, and explain Why? (7 marks)

QUESTION THREE

Among the factors influencing biomass gasification process and products,

TEMPERATURE appears to have the greatest influence on the performance of a gasifier. **AIR/FUEL** ratio is another key factor.

- (a) Outline, and discuss each in details, the influence of temperature on biomass gasification process and products. (15 marks)
- (b) Outline, and clearly explain each, the effects of Air/Fuel ratio on the final process-product gas. (5 marks)

QUESTION 4

- (a) Direct combustion is another thermochemical process for energy recovery/generation from suitable organic materials; yet it's a key stage in all thermochemical conversion processes.

Discuss in details, stage-by-stage, the **combustion process** of the primary biomass materials (e.g., firewood/fuelwood), showing all chemical reactions at each stage.

(13 marks)

- (b) **Fluidized-bed Gasifier** is one of the three common biomass gasifier.
Name the advantages and disadvantages of Fluidized-bed gasifier; giving examples where relevant. (7 marks)

QUESTION FIVE

Pyrolysis is a key process in thermochemical conversion of biomass because it is a stage in all biomass thermochemical processes, while it is a conversion process by itself.

It can be used to convert biomass to various forms of secondary biofuels.

- (a) (i) Name the factors that can be controlled to get one of the products carrying the largest fraction. (2 marks)
- (ii) Show the broad process-equation showing the final resultant products. (4 marks)
- (b) Name the pyrolysis technology (mode) that can be used to convert biomass to a **liquid fuel**, the operating conditions, broad name of the liquid product fuel and its component (i.e., what composes it). (7 marks)
- (c) Name the pyrolysis technology (mode) that can be used to convert biomass to a **gaseous fuel**, the operating conditions, the broad name of the gaseous fuel and its composition (i.e., what compose it). (7 marks)
