Number of pages: 04 **PG/2nd Sem./PGET 2103**

2023

BIOENERGY AND CONVERSION SYSTEMS

Full Marks: 100

Time: Three hours

The figures in the margin indicate full marks for the questions.

Answer all the questions.

1. Choose correct answer. [1 x 10 =10]

i) Which one of the following products is not obtained by the thermo-chemical conversion process?
   a) Syngas
   b) Producer gas
   c) Ethanol
   d) Biochar

ii) The main composition of biogas gas is
   a) O_2 and N_2
   b) CO_2 and H_2
   c) CO and H_2
   d) CH_4 and CO_2

iii) During anaerobic digestion process, accumulation of volatile fatty acid takes place
   a) Hydrolysis
   b) Acidogenesis
   c) Acetogenesis
   d) Methanogenesis

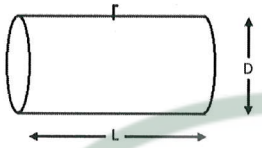
iv) Which one of the following is a feedstock for 2nd generation biodiesel production?
   a) Edible biomass
   b) Non-edible feedstock
   c) Algae
   d) None of the above

v) Which one of the following is not a feedstock for 1st generation biofuel production?
   a) Sugar cane
   b) Sweet sorghum
   c) Wheat
   d) Grass

vi) Bio-diesel is produced commercially by which of the following conversion process?

a) Gasification
b) Combustion
c) Transesterification
d) Pyrolysis

vii) The total plant volume of balloon-digester biogas plant (D=10 unit , L =20 unit) is



D=diameter, L =length

a) 1571
b) 447
c) 262
d) 1450

viii) The desired range of pH value for maximum biogas generation during anaerobic digestion process is

a) 5.5 - 6.0
b) 5.0 - 6.5
c) 6.8 - 7.3
d) 7.5 - 8.0

ix) Match the Groups I and II and choose the correct combination option from the following:

Group -I	Group -II
X. In Gasification	i. The presence of microorganisms is needed
Y. In Pyrolysis	ii. Partial oxygen is reqd.
Z. In Fermentation	iii. No oxygen is reqd.

a) X-ii, Y-i, Z-iii
b) X-i, Y-ii, Z-iii
c) X-iii, Y-ii, Z-i
d) X-ii, Y-iii, Z-i

x) The gas generated through the biomass gasification is called

a) Biogas
b) Producer gas
c) Carbon dioxide gas
d) Methane

2. Answer the following questions. [10 x 4 = 40]

a) What do you mean by biomass gasification? What are the ranges of temperature for different zones of gasification process of a downdraft gasifier? Write the four major gasification reactions. Also draw the schematics diagram of an downdraft type gasifier labelling the processes zones/steps in order. [2+2+4 +2 =10]

b) What is biodiesel? Write the different feedstocks used for the production of biodiesel. Draw and describe the method of biodiesel production. Write the differences between mechanical and solvent extraction. [2+2+2+4=10]

c) Write down the main operating parameters of biomass pyrolysis. How does the heating rate affect the pyrolysis process and product composition? Mention the different pre-treatment processes used for enhancing the efficiency of pyrolysis. How does pyrolysis contribute to waste management and recycling efforts? Write down the different applications of biochar. [2+2+2+2+2=10]

d) What is bioethanol? Write down the chemical reaction involved in sugar to ethanol production. What are the major differences between ethanol production from sugar crops and starch crops? How can the lignocellulosic biomass be pre-treated to enhance bioethanol production? [2+2+3+3=10]

3. Write short notes [5 x 4=20]

a) Biomass integrated gasification combined cycle (BIGCC).
b) Dual circulating fluidized bed gasifier.
c) Different steps of anaerobic digestion process.
d) Effect of temperature and pH value on anaerobic digestion process.

4. Solve the following problems. [30]

a) Consider a floating drum biogas plant has to be installed in a village. If the diameter and height of the digester are 3 m and 1.5 m, respectively. Calculate the
   i) Digester volume (V_d)
   ii) Gas storage volume (V_g)
   iii) Total plant volume (V_p) of the digester. [5]

b) Calculate the volume of the fixed dome type biogas digester for the output of the four cows. Also calculate the thermal power available from biogas. Consider the following data: [10]

Retention time = 30 days
Dry matter produced = 2 kg/day/cow
Biogas yield = 0.24 m^3/kg of dry matter
Percentage of dry matter in the cow dung = 18 %
Feedstock water ratio =1:1
Density of slurry =1090 kg/m^3
Burner efficiency = 60%
Heating value of biogas = 23 MJ/m^3
Assume, 10 % digester volume will be occupied by biogas.

c) A biomass gasifier is used to run a compression ignition (CI) engine. The engine operates in the dual-fuel mode with 85% diesel replacement. The gasifier engine system produces 350 kW of power. Calculate the biomass feeding rate to the gasifier if the calorific value of biomass is 16500 kJ/kg. Given that, the efficiencies of the gasifier and engines are 77% and 37%, respectively. [7]

d) Determine the amount of pure sugar (in kg) needed to generate 1 litre of pure ethanol from the equation. The density of pure ethanol is 0.789 g/cm^3. [8]

$$C_6H_{12}O_6 + Yeast \rightarrow 2C_2H_5OH + 2CO_2 + heat$$

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