Total No. of printed pages = 10

**19/2nd Sem/PGET 2103**



**2022**

# BIOENERGY AND CONVERSION SYSTEMS

Full Marks – 100

Time – Three hours

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

Answer any *five* questions.

## SECTION – A

1. Choose the correct answer : 1×15=15

(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 is

(a) $O_2$ and $N_2$ (b) $CO_2$ and $H_2$

(c) CO and $H_2$ (d) $CH_4$ and $CO_2$

[Turn over

(iii) During anaerobic digestion process, accumulation of volatile fatty acid (VFA) takes place

(a) Hydrolysis (b) Acidogenesis

(c) Acetogenesis (d) Methanogenesis

(iv) Which one of the following compounds is not used in the acid pre-treatment method for lignocellulosic biomass feedstock ?

(a) $H_2SO_4$ (b) $HNO_3$

(c) HCL (d) NaOH

(v) 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



(vi) Which one of the following is not a feedstock for 1st generation biofuel production ?

(a) Sugarcane (b) Sweet sorghum

(c) Wheat (d) Grass

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

(a) Gasification

(b) Combustion

(c) Transesterification

(d) Pyrolysis



(viii) The total plant volume (Vp) of a Fixed dome plant : Hemisphere Design Biogas Plant is

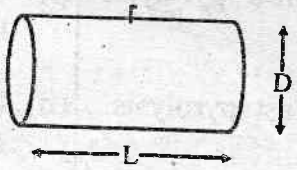
(a) $V_p = \frac{D^3}{2.236}$ $V_p = \frac{D^3}{2.236}$

(b) $V_p = \frac{2}{3}\pi\left(\frac{D}{2}\right)^3$ $V_p = \frac{2}{3}\pi\left(\frac{D}{2}\right)^3$

(c) $V_p = \pi\left(\frac{D}{2}\right)^3$ $V_p = \pi\left(\frac{D}{2}\right)^3$ D = diameter

(d) None of these

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




D = diameter, L = length

(a) 1571 (b) 447

(c) 262 (d) 1450

(x) From which one of the following biomasses, the ethanol production can be considered third-generation biofuel (ethanol) ?

(a) Woods (b) Sunflower

(c) Microalgae (d) Sugar beet

(xi) 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

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

| Group – I | Group – II |
|---|---|
| (X) Slow pyrolysis | (i) High yield of liquid fuel |
| (Y) Fast pyrolysis | (ii) Carbon-rich solid residue |
| (Z) Flash pyrolysis | (iii) Gases and bio-oil |

(a) (X)-(iii), (Y)-(i), (Z)-(ii)

(b) (X)-(i), (Y)-(ii), (Z)-(iii)

(c) (X)-(iii), (Y)-(ii), (Z)-(i)

(d) (X)-(ii), (Y)-(i), (Z)-(iii)

(xiii) 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 required. |
| (Z) In Fermentation | (iii) No oxygen is required. |

(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)

(xiv) The gas generated through the biomass gasification is called

(a) Biogas

(b) Producer gas

(c) Carbon dioxide gas

(d) Methane



(xv) Gasification of biomass is which type of conversion process ?

(a) Chemical (b) Biochemical

(c) Biological (d) Thermo-chemical.

## SECTION – B

2. Explain any *five* of following : 5×5=25

(a) Second generation biofuel production process.

(b) Biomass integrated gasification combined cycle (BIGCC).

(c) Dual circulating fluidized bed gasifier.

(d) Different stages of slow pyrolysis process.

(e) Different steps of anaerobic digestion process.

(f) Biodiesel production process.



3. Answer the following questions : 10×2=20

(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 updraft type gasifier labelling the processes zones/steps in order. 2+2+4+2=10

(b) What is the main objective of the pre-treatment process of a lignocellulosic biomass ? Why chemical pretreatment method is not feasible for biodegradable feedstocks ? Write the name of any four alkaline compounds that are used for alkaline pretreatment method. Also write the advantages and disadvantages of combined pretreatment method over single pretreatment method. 2+2+2+4=10

## SECTION – C

4. Solve the following problems : 40

(a) A pyrolysis experiment showed that the bio-oil yield was 85% by weight. If the density of the bio-oil was found to be 1.5 kg/L, calculate the bio-oil yield in litres/ton. 3

(b) 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

(c) 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 : 5

(i) Digester volume ($V_d$)

(ii) Gas storage volume ($V_g$)

(iii) Total plant volume ($V_p$) of the digester.

(d) 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.



(e) Estimate the biochar, bio-oil and syngas yields at 500°C operating temperatures for microalgae in units of kg/tonne, L/tonne and L/tonne, respectively. Use the data in Table 1 and assume the average density of bio-oil to be about 840 $kg/m^3$ and that of the syngas to be 0.661 $kg/m^3$. 5

Table 1

| Temperature (°C) | Syngas Yield (% w/w) | Bio-oil Yield (% w/w) | Biochar Yield (% w/w) | Losses (% w/w) |
|---|---|---|---|---|
| 400 | 4.0 | 19.0 | 51.8 | 25.2 |
| 500 | 10.9 | 27.6 | 34.4 | 27.1 |
| 600 | 14.8 | 23.2 | 35.8 | 26.2 |

(f) Sweet sorghum stalks were pressed to obtain 1 L of the juice (mass, 1 kg). It was then filtered and analysed on HPLC. The total sugar concentration was found to be 140 g/L. The juice was further fermented using yeast and produced an ethanol concentration of 65 g/L, as analysed on HPLC. Determine the ethanol yield per weight of juice and that of sugar as the substrate. 5

(g) One pathway of lignocellulosic biomass to ethanol production reported 350 L/dry ton of lignocellulosic biomass. How many litres per year will be produced by 405 ha of woody biomass that has a yield of 46 ton/ha/yr. The biomass has 35% moisture after harvest. 5