Form No. T611

Philadelphia University
Faculty of Engineering

Student Name:
Student Number:

Dept. of Alternative Energy Technology
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Course Title: Bioenergy and Waste Management	**Date: 21/6/2022**
Course No: (615446)	**Time Allowed: 2 Hours**
Lecturer: Dr. Mohammad Abu-Naser	**No. of Pages: 4**

Question 1: ***(10Mark)***

Objectives: This question is related to Biogas

a) Write the equation of anaerobic digestion in words and in chemical symbols

Words:

Glocuse → Carbon Dioxide + Methane

Chemical symbols:

$$C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$$

b) In the table below connect each temperature to the appropriate range and the corresponding retention time.

Temperature	Range	Retention time
Psychrophilic	20°C to 40°C	15 days to 25 days
Mesophilic	40°C to 60°C	40 days to 100 days
Thermophilic	10°C to 20°C	25 days to 40 days

c) What are the feedstock pre-treatment processes?

- Sorting
- Particle size reduction
- Addition of water

d) What are the biogas post-treatment processes?

- Dewatering
- CO_2 removal

e) What are the digestate post-treatment processes?

- Hygienization
- Safe discarding

Question 2: ***(5Mark)***

Objectives: This question is related to Biogas calculations

Food waste is generated at a rate of 50 kg/day. TS=15% and VS=90%. Food waste is diluted with water at a ratio of 1:2. The hydraulic retention time is 30 days. If the methane yield is 0.4 m^3/kg VS, calculate:

1) The volume of the reactor?
2) The methane production rate?

Clearly indicate all units of the final answer

1) Food waste input rate = 50 kg/day ≈ 50 L/ day
   Added water rate = 100 L/day
   Total input flow rate Q = 50 + 100 = 150 L/day

   Active volume $\Rightarrow V = Q \times HRT = 150 \frac{L}{day} \times 30\, day = 4500\, L = 4.5\, m^3$

   Add 25% of volume to store gas = 1.5m³

   So total volume V = 4.5 + 1.5 = 6 m³

2) $S = \frac{0.15 \times 0.9}{3} = 0.045\, kg/L = 45\, kg_{VS}/m^3$

   $Q_{CH_4} = S \times SGP \times Q = 45 \times 0.4 \times 0.15 = 2.7\, m^3/day$

Question 3: ***(7Mark)***

Objectives: This question is related to basics of bioenergy

a) Write four factors that affect crop yield
   - Location
   - Climate
   - Weather
   - Nature of the soil
   - Supplies of water
   - Nutrients
   - Choice of plants (species and strain)

b) What is the most important sugary biomass used for ethanol production in Europe?
   Sweet beet

c) What is the most important sugary biomass used for ethanol production in Brazil?
   Sugarcane

d) What is the most important starchy biomass used for ethanol production in USA?
   Corn

e) What is the most important oily biomass used for biodiesel production in USA?
   Soybean

f) What is the most important oily biomass used for biodiesel production in Europe?
   Rapeseed

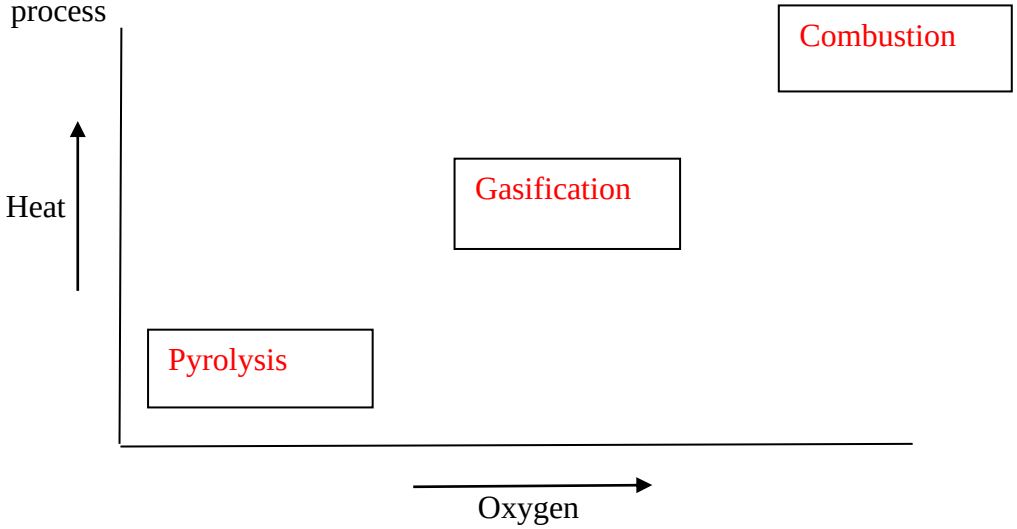
Question 4: ***(10Mark)***

Objectives: This question is related to thermochemical conversion processes

a) What are the three thermochemical conversion processes? And compare between their temperatures and oxygen requirements.

Process	Temperature	Endothermic/exothermic	Oxygen requirement
Combustion	Highest	Exothermic	High
Gasification	Lower	Endothermic	Low
Pyrolysis	Lowest	Endothermic	None

b) In the graph below fill the box with the appropriate thermochemical conversion process



c) What are the two advantages of thermochemical conversion processes?

- Flexibility of feedstock
- Flexibility of produced fuel

d) What is the main disadvantage of thermochemical conversion processes?

- Requires significant energy input

Question 5: ***(8Mark)***

Objectives: This question is related to multiple choices

1) Transesterification is used in the production of
   a. Ethanol
   b. Biogas
   c. Syngas
   d. Biodiesel

2) What is the most valuable form of fuel?
   a. Solid
   b. Gas
   c. Liquid
   d. All have the same value

3) Which of the following true about ethanol?
   a. Reduce engine knocking
   b. Renewable
   c. Has lower energy density than gasoline
   d. All of the above

4) What is the chemical formula for ethanol?
   a. CH_3OH
   b. $C_6H_{12}O_6$
   c. $C_{12}H_{22}O_{11}$
   d. C_2H_5OH

5) Fermentation by yeast is used in the production of
   a. Biodiesel
   b. Biogas
   c. Ethanol
   d. Syngas

6) What does digestate resulting from anaerobic digestion in farms used for?
   a. Produce heat for distillation
   b. Produce Biodiesel
   c. Produce Cellulose
   d. Fertilizers for plants

7) A process that occurs in landfills and wastewater treatment plants is
   a. Anaerobic digestion
   b. Photosynthesis
   c. Combustion
   d. Gasification

8) Which of the following the major process for plant growth?
   e. Fermentation
   f. Photosynthesis
   g. Transesterification
   h. Anaerobic digestion