



Philadelphia University  
Faculty of Engineering

Student Name:  
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Dept. of Renewable Energy Engineering  
Final Exam, Second Semester: 2021/2022

Course Title: Bioenergy Systems	Date: 15/6/2022
Course No: (611541)	Time Allowed: 2 Hours
Lecturer: Dr. Mohammad Abu-Naser	No. of Pages: 4

**Question 1:** **(5Mark)**

**Objectives:** This question is related to Biogas

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

Words:



Chemical symbols:



b) In the table below connect the AD process parameters/reactor condition in the right and left columns

Temperature	Batch and continuous
Feeding mode	Wet and solid
Digester technology	Thermophilic and mesophilic
Content	Fixed dome and floating drum

**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<sup>3</sup>/kg VS, calculate:

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

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 = 1.5m<sup>3</sup>

So total volume V = 4.5 + 1.5 = 6 m<sup>3</sup>

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:

(10Mark)

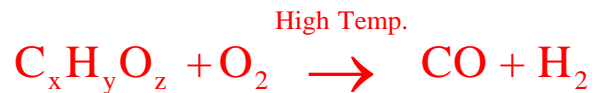
**Objectives: This question is related to thermochemical conversion processes**

a) Write the gasification equation in words and in chemical symbols

Words:



Chemical symbols:



b) Write the Fischer-Tropsch equation in words and in chemical symbols

Words:



Chemical symbols:



c) What are the two most important benefits of gasification/Fischer-Tropsch processes?

- Flexibility of feedstock
- Flexibility of produced fuel

d) What is the main disadvantage of gasification process?

- Requires significant energy input

e) What are the three factors that determines the produced fuel in the Fischer-Tropsch synthesis?

- Type of catalyst
- Reaction duration
- CO/H<sub>2</sub> ratio

**Question 4:**

**(10Mark)**

**Objectives: This question is related to Algae**

a) Write four major advantages of algae over terrestrial plants

- a. Higher yield per acre
- b. Fungible fuels: wide range of biofuels: gasoline, diesel, jet fuel
- c. Less environmental impact
- d. Lipids as high as 50-60% of dry weight

b) Write four important traits desired in the development of future algae strains

- a. High growth rate
- b. Water salt tolerance
- c. Heat tolerance
- d. Pest resistance

c) Fill the following table that compares between two technologies of algae production

	Open ponds	Photobioreactors
Cost	Cheap	Expensive
Crop protection	Harder	Easier

**Question 5:**

**(10Mark)**

**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) Which of the following is a desirable characteristic in plant growth?

- a. Increased plant height
- b. Production of less leaves
- c. Shortened growth duration
- d. Increased plant height and production of less leaves

3) What is the most valuable form of fuel?

- a. Solid
- b. Gas
- c. Liquid
- d. All have the same value

- 4) Which of the following true about ethanol?
- Reduce engine knocking
  - Renewable
  - Has lower energy density than gasoline
  - All of the above**
- 5) From longest to shortest carbon chain length, what is the correct order?
- Ethanol, diesel, gasoline
  - Diesel, gasoline, ethanol**
  - Gasoline, ethanol, diesel
  - Gasoline, diesel, ethanol
- 6) What is the chemical formula for ethanol?
- $\text{CH}_3\text{OH}$
  - $\text{C}_6\text{H}_{12}\text{O}_6$
  - $\text{C}_{12}\text{H}_{22}\text{O}_{11}$
  - $\text{C}_2\text{H}_5\text{OH}$**
- 7) Fermentation by yeast is used in the production of
- Biodiesel
  - Biogas
  - Ethanol**
  - Syngas
- 8) What does bagasse resulting from sugarcane in Brazil used for?
- Produce heat for distillation**
  - Produce Biodiesel
  - Produce Cellulose
  - Fertilizers for plants
- 9) What does digestate resulting from anaerobic digestion in farms used for?
- Produce heat for distillation
  - Produce Biodiesel
  - Produce Cellulose
  - Fertilizers for plants**
- 10) A process that occurs in landfills and wastewater treatment plants is
- Anaerobic digestion**
  - Photosynthesis
  - Combustion
  - Gasification