



### **QUESTION ONE (COMPULSORY) (30 Marks)**

- a. Define the following terms:
- Ligno-cellulosic biomass. (1 Mark)
  - Bulk density. (1 Mark)
  - Heat of formation. (1 Mark)
  - Proximate Analysis. (1 Mark)
- b. Using Table 1 provided, solve the heat of formation of sorghum waste given that the heating value is 286 KJ/mol. Assume its chemical formula to be  $\text{CH}_{1.35}\text{O}_{0.528}$ . (6 Marks)

*Table 1. Heat of formation of various compounds*

Compound	H <sub>2</sub> O	CO <sub>2</sub>	CO	CH <sub>4</sub>	O <sub>2</sub>	CaCO <sub>3</sub>	NH <sub>3</sub>
Heat of formation at 25 °C (kJ/mole)	-241.5	-393.5	-110.6	-74.8	0	-1211.8	-82.5

- c. Examine four factors affecting biogas generation. (4 Marks)
- d. Using a diagram, illustrate a conventional updraft gasifier and label stages clearly stating resultant products. (8 Marks)
- e. Using Biodiesel as a biofuel, show how biodiesel is used as a petroleum additive. (2 Marks)
- f. Biogas is generated by fermentation or digestion of organic matter. Illustrate key steps involved. (6 Marks)

### **QUESTION TWO (20 Marks)**

- a. Examine the constituents of biomass cell. (6 Marks)
- b. Compare and contrast direct co-firing and indirect co-firing as a strategy for reducing CO<sub>2</sub> emissions in bioenergy production. (4 Marks)
- c. Illustrate using a diagram ethanol production from maize cob farming in Bondo area via wet milling process (10 Marks)

### **QUESTION THREE (20 Marks)**

- a. Using illustrations, examine the term atomic ratio as used in the classification of biomass fuels. (4 Marks)
- b. Examine four bases of expressing biomass composition. (4 Marks)
- c. Compare and contrast Refuse Derived Fuel (RDF) and Solid Recovered Fuel (SRF). (2 Marks)
- d. In a biogas system, biogas is generated by fermentation or digestion of organic matter in the presence of aerobic and anaerobic micro-organisms. Examine these digestion process steps. (6 Marks)

- e. Bondo County community-based group have designed a specific stove for household use as shown in Figure 1. Examine four key design principles that have been observed. (4 Marks)



*Figure 1. Designed stove.*

**QUESTION FOUR (20 Marks)**

- a. Examine three particular energy crops grown in Kenya. (3 Marks)
- b. Using illustrations, examine two major thermochemical conversion processes, giving examples. (6 Marks)
- c. Calculate the size of a fixed dome biogas plant (digester and gas holder) and the amount of biogas produced by the plant. Clearly specify assumptions made. Given, (11 Marks)
- a small household with three (3) cows – zero grazed
  - 10 kg of dung per cow in a day
  - total solid (TS) is estimated at 20%
  - volatile solid (VS) estimated at 80% of TS
  - cattle manure biogas yield/kg: 0.35
  - optimum mixing ratio, dung: water (1:3)

**QUESTION FIVE (20 Marks)**

- a. You have designed and constructed a new cooking stove or ‘jiko’ as your final year project. Using your constructed stove, examine a procedure (s) for ascertaining efficiency of this particular cooking device. Clearly specify your assumptions. (10 Marks)
- b. Illustrate using a diagram the production of bio-oil from available biomass materials in Siaya County. (10 Marks)