Question One

(a) Some power stations burn wood instead of fossil fuels to generate electricity. **3 Marks**

A coal-burning power station burns 6 million tonnes of coal per year.
Coal has an average energy value of 29.25 MJ/ kg.
Wood chip from willow trees has an energy value of 13 MJ / kg.

A hectare of agricultural land can produce 9 tonnes of dry willow wood per year.
If this power station burned dry willow wood instead of coal, how much agricultural land would be needed to grow the willow?

(b) The table below shows the carbon dioxide emissions of four fuels used to generate electricity. **2 Marks**

Fuel	Direct CO2 emissions in kg per MWh	Lifecycle CO2 emissions in kg per MWh
Coal	460	540
Natural gas	185	215
Oil	264	313
Wood	2 100	58

Direct CO_2 emissions are the amounts of carbon dioxide released when the fuel is burned.
Lifecycle CO_2 emissions is the total amount of carbon dioxide released during all stages from fuel extraction to when the fuel has been used.
Use the data from the table above to explain why wood is considered to be a low carbon dioxide emitting fuel.

(c) A farmer plans to generate all the electricity needed on her farm, using either a biogas generator or a small wind turbine. **6 Marks**
The biogas generator would burn methane gas. The methane gas would come from rotting the animal waste produced on the farm. When burnt, methane produces carbon dioxide.
The biogas generator would cost KES 220 000 to buy and install. The wind turbine would cost KES 350 000 to buy and install.
The **average power** output from the wind turbine would be the same as the **continuous output** from the biogas generator.
Evaluate the advantages and disadvantages of the two methods of generating electricity.
Conclude, with a reason, which system would be better for the farmer to buy and install.

(d) Identify any THREE energy services in rural areas that can be satisfied by **6 Marks**

biomass energy sources. Provide a brief explanation

(e) Explain some of the concerns regarding the growth of crops for the production of biofuels **5 Marks**

(f) Explain the traditional method of charcoal production **2 Marks**

(g) Is this traditional method closely related to industrial gasification or pyrolysis? Explain **6 Marks**

Question Two

You have been approached by a rural farming community to advice on feasibility of setting up a biomass power plant in their area.

You ask for some time during which you collect and analyze data in order to form an opinion.

(a) Explain the type of data you need to collect **5 Marks**

(b) Describe how you go about collecting the data **5 Marks**

(c) Describe how you analyze the data in order to form your opinion **5 Marks**

(d) Give an outline of the report you submit to the community **5 Marks**

Question Three

(a) (i) If a wood burner with an efficiency of 60% and a heat output of 5 kW is used to heat a room for 6h a day, how much wood of CV 15MJ/kg is required per day? **4 Marks**

(ii) If the stove is used for 6 months of the year, how much land might be needed to grow the required wood each year based on general managed woodlands and Short Rotation Coppice (SRC) Willow? **4 Marks**

General Managed woodland products: 3t/ha annually

Shor Rotation Coppice (SRC) Willow: 13t/ha annually

(b) A community of 6000 households proposes to construct a power plant based on 5000 of MSW that it produces each year.

(i) The average CV of MSW is 9GJ/t. If the overall waste-to-electricity conversion efficiency is 30%, how many MJ a year will the plant produce, running continuously? **4 Marks**

Question Four

In a rural area, a biomass-burning power plant is supplied with wood from a managed plantation. 1850 tonnes/year of wood are supplied and the wood has a CV of 16MJ/kg. The efficiency of electricity generation is 30% and the plant requires 40 kW of electricity to run its pumps and furnace equipment.

(a) What is the net electricity output and the overall efficiency of the plant? 10 Marks

(b) What factors would determine whether it would be desirable to have a Combined Heat and Power (CHP) plant rather than a power plant for electricity production alone? 5 Marks

(C) (i) How could a power system based on biomass combustion be truly sustainable and carbon neutral? 2 Marks

(ii) Why do real biomass power systems usually have a small but significant carbon footprint? 3 Marks

Question Five

(a) Raw biomass is often directly burnt to produce heat. In other cases, methods have been devised to convert the biomass into other forms of biofuel. Discuss briefly the benefits of processing biomass rather burning it directly **6 Marks**

(b) Briefly discuss the following in terms of biofuel production

(i) Pyrolysis **4 Marks**

(ii) Anaerobic Digestion **4 Marks**

(c) A large amount of biomass waste is dumped in landfill (dumpsite) sites every day. Clearly, this method of waste disposal is not good for the environment. Alternatively, energy schemes have been based on landfills. Explain how this is possible and briefly discuss the relative merits for such schemes. **6 Marks**