WNTER-19 EXAMINATION

Model Answer

Subject title: Renewable Energy Technologies Subject code 22514

Important Instructions to examiners:

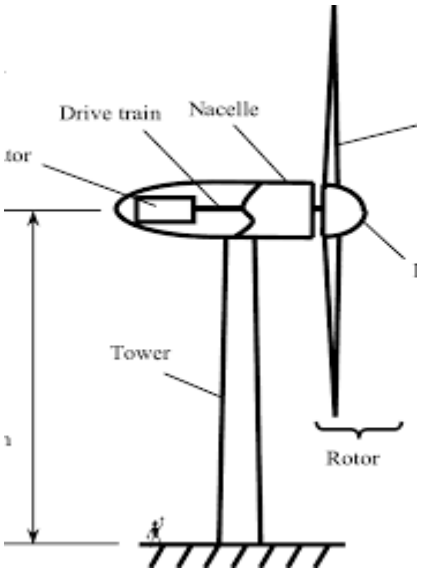
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

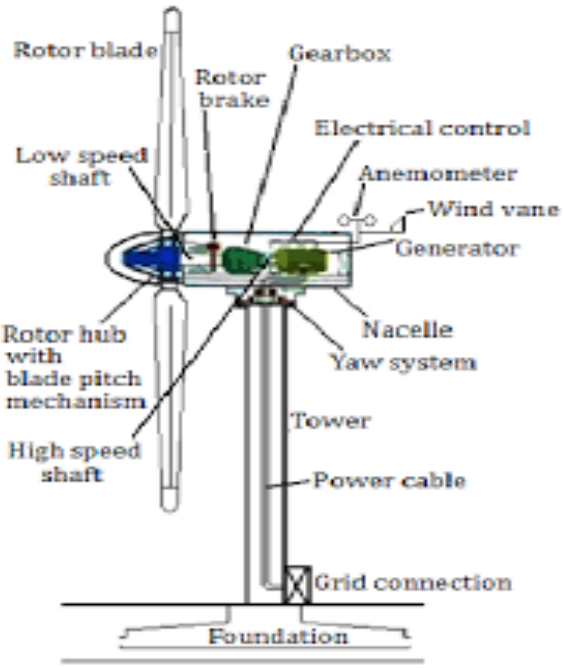
Q No.		Answer	Marking scheme
1		**Attempt any FIVE**	**10**
1	a	**Write names of parts of wind turbine.(any four)** Tower Blades Hub Rotor Shaft Gearbox Generator Controller Brake Anemometer Nacelle Yaw drive mechanism etc.	½ for each
1	b	**Write any four advantages of wind power.** Air as a fuel is free and inexhaustible. It is a clean source of energy and does not pollute the environment. The cost of electricity is low and wind turbine could be used over more than 20 years. It is cheap as only the installation and maintenance cost is required. Wind energy is one of the fastest growing sectors all around the globe , so it is generating a lot of employment in manufacturing , installation and	½ for each

		maintenance.	
1	c	**List any two features of wind solar hybrid system.** It is easy to operate , service and maintenance. Most economically and clean source of energy. No pollution and no fuel cost. Long life span. Highly reliable and consistent power supply. Safe for public and safe working environment. Very few moving parts. Remote and rural village electrification. Ideal for mobile towers , farm house , hospitals etc.	1 for each
1	d	**Write names of any four sources of biomass.** Biomass is renewable energy resource derived from plant and algae based that include – Crop wastes Forest residues Food waste Purpose grown grasses Woody energy crops Micro-algae urban wood waste etc.	½ for each
1	e	**Name the gases present in biomass.** The gas present in biomass is a mixture of – Methane (70-75%) Carbon dioxide (10-15%) Water vapours (5-10%)	2 marks

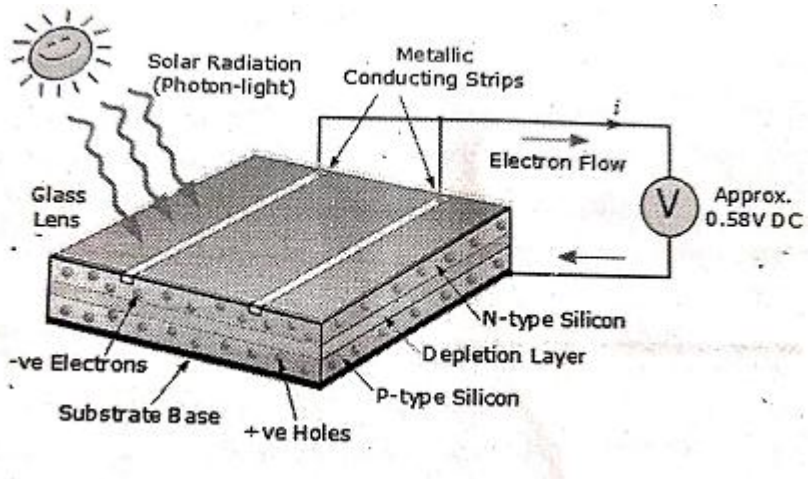
1	f	**Write any four merits of bio energy.** Emits little or no greenhouse gas emissions. Is a useful way of managing waste disposal matter that would otherwise be scrapped. Has well-established technology to deliver reliable energy. Can be stored with minimal energy loss. Is plentiful wherever there are agricultural crops and forestry. Can help to stabilize soils , improve soil fertility and reduce erosion. Reduce needs for fossil fuels for the production of heat , steam and electricity for residential , agricultural and industrial use. Always available and can be produced as a renewable resource. Growing biomass crops produce oxygen and use of carbon dioxide. Always and widely available as a renewable resource of energy. Is a carbon neutral. Is less expensive than fossil fuels. Adds a revenue source for manufacturers. Dispose less garbage in landfills. Reduces the over-reliance of fossil fuels.	½ for each
1	g	**List any two types of micro-hydro power plants.** A) base on use – Conventional plants Pumped storage plants Run-of-river plants. B) based on size – Large hydro power plants (capacity more than 100MW)	1 for each

		Medium hydro power plants (capacity 15 to 100MW) Small hydro power plants (capacity 1 to 15MW) Mini hydro power plants (capacity 100 KW to 1MW) Micro hydro power plants (capacity 5KW to 100KW) Pico hydro power plants (capacity less than 5 KW)	
2		**Attempt any THREE**	**12**
2	a	**List the types of wind turbines and explain HAWT.** **Types of Wind Turbines** On the basis of axis of rotation of the blades, it is divided into two parts. 1. Horizontal axis wind turbine (HAWT) 2. Vertical axis wind turbine (VAWT) ***Horizontal Axis Wind Turbine (HAWT)*** It is a turbine in which the axis of rotation of rotor is parallel to the ground and also parallel to wind direction. ▪ Horizontal axis wind turbines (HAWT) are the predominant turbine design in use today. The HAWT rotor comprises blades (usually three) symmetrically mounted to a hub. The rotor is connected via a shaft to a gearbox, and the generator is housed within the nacelle. The nacelle is mounted atop a tower connected to a concrete foundation. ▪ HAWT come in a variety of sizes, ranging from 2.5 meters in diameter and 1 kW for residential applications up to 100+ meters in diameter and over 3.5 MW for offshore applications. The theoretical maximum efficiency of a HAWT is ~59%, also known as the Betz Limit. Most HAWT extract about 50% of the energy from the wind that passes through the rotor area. The capacity factor of a wind turbine is its	1 mark 3

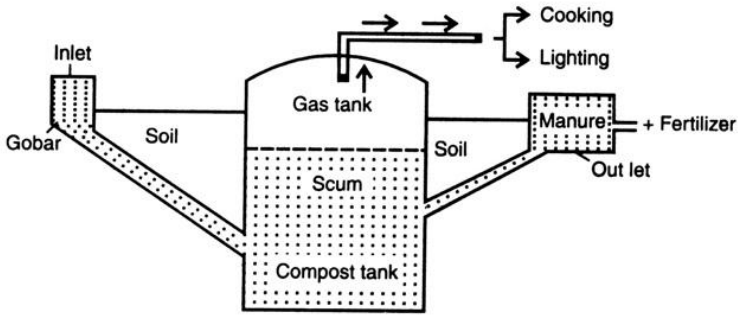
		average power output divided by its maximum power capability. On land, capacity factors range from 0.26 to 0.52. Offshore winds are generally stronger than on land, and capacity factors are higher on average, but offshore wind farms are more expensive to build and maintain. Offshore turbines are currently placed in depths up to 40-50m (about 131-164ft).  They are further divided into two types (i) Upwind turbine (ii) Downwind turbine	
2	b	**Draw neat sketch of wind turbine and name various parts in it.**	

			4 marks
2	c	**Write the functions of :** **i) Blades –** Convert wind energy into usable mechanical energy. Aerodynamically optimized structure of blades help to capture maximum wind power even in normal operation. **ii) Nacelle –** Protects turbine's internal components from surrounding environment. **iii) Shaft –** low speed – transfers mechanical energy to gear box. high speed – drives the generator. **iv) Gear box –** Controls rotational speed of generator.	1 1 1 1
2	d	**Differentiate between horizontal axis and vertical axis wind turbine.**	

		Difference between Horizontal Axis Wind Turbine and Vertical Axis Wind Turbine S.no | Horizontal Axis Wind Turbine | Vertical Axis Wind Turbine 1. | In HAWTs, the axis of rotation of the rotor is Horizontal to the ground. | In VAWTs the axis of rotation of the rotor is perpendicular to the ground. 2. | Yaw mechanism is present. | Absence of Yaw mechanism. 3. | It has high initial installation cost. | It has low initial installation cost. 4. | They are big in size. | They are small in size. 5. | Its efficiency is high. | It has low efficiency. 6. | It requires large ground area for installation. | It requires less ground area for installation. 7. | High maintenance cost. | Low maintenance cost as compared with HAWT. 8. | They are self-starting. | They are not self-starting. 9. | They are unable to work in low wind speed condition. | They are capable of working in low wind speed condition. 10. | Difficult in transportation. | Easy in transportation. 11. | They are mostly used commercially. | They are mostly used for private purpose only. 12. | It cannot be installed near human population. | It can be installed near human population. 13. | It is not good for the bird's population. | It is good for the bird's population.	1 mark each for any 4
3		**Attempt any three**	**12**
3	a	**Solar distillation:** Solar water distillation is the process of using energy from sunlight to separate fresh water from salts or other contaminants. The untreated water absorbs heat, slowly reaching high temperatures. The heat causes the water to evaporate, cool, and condense into vapour, leaving the contaminants behind. Solar stills can be used for low capacity and self- reliant water supplying systems. A solar still works on two scientific principles- evaporation and condensation.	4

		The salts and minerals do not evaporate with the water. For example, table salt does not turn into vapour until it gets to a temperature over 1400^0C. However it still does take a certain amount of energy for water to turn into water vapour. While a certain amount of energy is needed to raise the temperature of a kilogram of water from 0^0C to 100^0C, it takes five and one half times that much to change it from water at 100^0C to water vapour at 100^0C. Practically all this energy, however, is given back when the water vapour condenses. Most stills are simple black bottomed vessels filled with water and topped with clear glass or plastic. Sunlight that is absorbed by the balck material speeds the rate of evaporation. The evaporation is then trapped by the clear topping and funneled away. Most polltants do not evaporate, so they are left behind. Most stills need to be about six m^2 in size to produce enough water for a single person for a day. Multiple solar distillation systems are required to produce a large quantity of distilled water.	
3	b	**Solar cell**:  **Working:**	2

		It is the direct conversion of light into electricity at the atomic level. The photovoltaic effect is a process that generates voltage or electric current in a photovoltaic cell when it is exposed to sunlight. Photovoltaic cell need to establish an electric field. Much like a magnetic field, which occurs due to opposite poles, an electric field occurs when opposite charges are separated. To get this field, manufacturers dope silicon with other materials, giving each slice of the sandwich a positive or negative electrical charge. Specifically they seed phosphorous into the top layer of silicon, which adds extra electrons, with a negative charge, to that layer. Meanwhile, the bottom layer gets a dose of boron, which results in fewer electrons, or a positive charge. This all adds up to an electric field at the junction between the silicon layers. Then, when a photon of sunlight knocks an electron free, the electric field will push that electron out of the silicon junction.	2
3	c	**Solar Water Heater** **Construction** A typical domestic solar water heater consists of a hot water storage tank and one or more flat plate collectors. Inlet and outlet pipes are connected to water tank which is insulated to avoid heat loss. Material of construction of tube is copper in side collector. Glass cover is provided on the collector. Water is place on the metal structure at the top and flat plate collectors are the bottom facing the sun. **Working** The collectors are glazed on the sun facing side to allow solar radiation to come in. A black absorbing surface (absorber) inside the flat plate collectors absorbs solar radiation and transfers the energy to water flowing through it. A	4

		black surface heats up when left in the sun, by absorption of solar radiation; The good absorption property of black surfaces is used to improve solar energy absorption in a solar heater Heated water is collected in the tank which is insulated to prevent heat loss. Circulation of water from the tank through the collectors and back to the tank continues automatically due to density difference between hot and cold water (thermosyphon effect).	
3	d	**Uses of solar thermal energy in industry:** 1. Solar distillation 2. Solar drying 3. Solar cooling 4. Solar radiation into cooling or air- conditioning	4
4		**Attempt any three**	**12**
4	a	**Bio gas plant:** 	4
4	b	**Biomass power plant:** Biomass is a versatile renewable energy source. It can be converted into liquid transportation fuels that are equivalent to fossil- based fuels, such as gasoline, jet and diesel fuel. Bioenergy technologies enable the reuse of carbon from biomass and waste streams into reduced- emission fuels for cars, trucks, jets and ships; bio products and renewable power. In many ways biomass is a	4

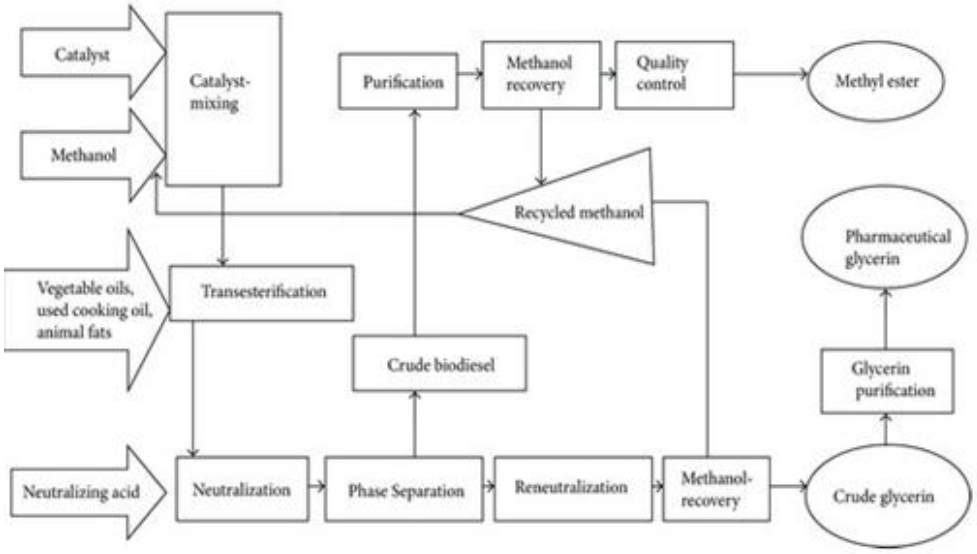
		unique renewable resource. It can be stored and transported relatively easily in contrast to renewable options such as wind and solar, which create intermittent electrical power that requires immediate consumption and a connection to the grid. With the exception of waste and residue, the cost of biomass often represent a significant share of the production cost of bio energy. One or more conversion steps are needed to transform raw biomass into consumable bio energy products and services. As it grows, plant biomass captures solar energy and converts it to chemical energy stored in the chemical bonds of its molecular constituents. This chemical energy can be either directly released as heat via combustion or converted into a variety of marketable intermediate chemical and energy products. A bio energy chain consists of a series of conversions steps by which a raw biomass feed stock is transformed into a final energy product(heat, electricity or transport biofuel). Common biomass conversion processes include: 1. Combustion: the process by which flammable materials are burned in the presence of air or oxygen to release heat. 2. Gasification: is the conversion of biomass into a combustible gas mixture referred to as producer gas. 3. Pyrolysis: consists of thermal decomposition in the absence of oxygen. 4. Anaerobic digestion: is the process whereby bacteria break down organic material in the absence of air, yielding a biogas containing methane and a solid residue. 5. Fermentation: involves the conversion of a plant's glucose into an alcohol or acid.	

		Biogas plants rely on anaerobic digestion, a fermentation process in which waste is digested by microbes to produce methane gas. The waste can be converted into bio fertilizer and spread directly onto fields, or the bio gas itself can be used interchangeably with natural gas as fuel.	
4	c	**Working of wood gasifier:** The term Gasification is used for chemical processes by which a gaseous fuel is produced from a solid fuel. Wood gas was used for heating, lighting and even as vehicle fuel. There are many different designs of modern gasifier, but essentially one basic process: hot steam and oxygen interacting with the solid fuel. The gasification reaction do not occur easily, and need operating temperatures from a few hundred to over a thousand degree Celsius, with pressures from a little above atmospheric pressure to 30 times this. The process begins with the release of the volatiles from the heated solid, leaving the char. These two components in turn undergo reactions with steam and oxygen, resulting in producer gas, a mixture of combustible components together with carbon dioxide and water. Further processing may break down some of the combustibles to give a cleaner gas. Nitrogen will also be present if air is used, rather than oxygen, and the energy content of the resulting gas is then only 3-5MJ/m^3, about a tenth of that of natural gas.	4
4	d	**Problems for converting municipal solid waste into power:** 1. Municipal solid waste is a mixture, it may contain materials containing chlorine, which causes dioxin on processing which causes pollution. 2. Proper segregation is required. 3. Removal of oversized items and non- combustible metallic materials	1 mark each for any 4

		are to be removed. 4. Capital cost of the plant is high. 5. After combustion, the incinerators ash and other pollutants removal system must be capable of disposing of every bit of the size and capacity of the combusted material coming out of the incinerator as it is going in	
4	e	**Advantages of biomass power generation: (any 2)** 1. Emits little or no net greenhouse gas emissions 2. Is a useful way of managing waste disposal for matter that would otherwise be debris. 3. Has well established technology that is able to deliver reliable energy. 4. Can be stored with minimal energy loss. 5. Biomass used as a fuel reduces need for fossil fuels for the production of heat, steam, and electricity for residential, industrial and agricultural use. 6. Biomass is always available and can be produced as a renewable resource. 7. Biomass fuel from agriculture wastes may be a secondary product that adds value to agricultural crop. 8. Growing biomass crops produce oxygen and use up carbon dioxide. **Disadvantages of biomass power generation: (any 2)** 1. Is generally a more expensive energy source compared to fossil fuels, because it requires more fuel to produce the same amount of energy. 2. Uses a lot of wood from natural forest which can lead to deforestation, and if wood is not fully burnt it can release soot like particles that may	1 mark each 1 mark each

		cause widespread air pollution. 3. Can be expensive when taking into account the cost of harvesting, extracting, transporting and handling biomass. 4. Agricultural waste will not be available if the basic crop is no longer grown. 5. Land used for energy crops may be in demand for other purposes.	
5		**Attempt any TWO**	**12**
5	a	**Explain production of biodiesel from Jatropha seeds.** ***Source of jatropha Oil:*** The plant that is generally cultivated for the purpose of extracting jatropha oil is Jatropha curcas. The seeds are the primary source from which the oil is extracted. Owing to the toxicity of jatropha seeds, they are not used by humans. The major goal of jatropha cultivation, therefore, is performed for the sake of extracting jatropha oil. Analysis of jatropha curcus seed shows the following chemical compositions. Moisture: 6.20% Protein: 18.00% Fat: 38.00% Carbohydrates: 17.00% Fiber: 15.50% Ash: 5.30% The oil content is 25-30% in the seed. The oil contains 21% saturated fatty acids and 79% unsaturated fatty acids. These are some of the chemical elements in the seed, cursin, which is poisonous and render the oil not appropriate for human consumption. Oil has very high saponification value and being extensively used for making soap in some countries. Also oil is used as an illuminant in lamps as it burns without emitting smoke. It is also used as fuel in place of, or along with kerosene stoves. Jatropha curcus oil cake is rich in Nitrogen, Phosphorous and Potassium and can be used as organic manure.	2 marks

Production of Biodiesel



Production of biodiesel.

2 marks

Process Biodiesel is produced by chemically reacting vegetable oil/ animal fat with alcohol to produce a new compound called fatty acid alkyl ester by trans-esterification. A catalyst such as sodium/potassium hydroxide is used and glycerol is obtained as by-product. Methanol is recovered in the process.

2 marks

The main trans-esterification reaction using methanol is carried out in stainless steel reaction tank. The required amount of jatropha oil was filtered, measured and poured into the conical bottomed reactor tank. Jatropha oil was heated to the required temperature and the alkoxide solution (NaOH/kOH) was prepared simultaneously. The prepared alkoxide solution was introduced into the reactor and the mixture was stirred vigorously for required reaction time. After that, the reaction was stopped and the mixture was allowed to settle in the separation tank for 12 hours. After settling the mixture for 12

		hours, it was separated into two layers. The lower glycerine layer was drawn off from the bottom of the settling tank. Then, the crude biodiesel was pumped into the washing tank. It was equipped with a stirrer. The crude biodiesel layer was needed to purify by washing with warm water. First, the catalyst residue in the biodiesel layer was neutralized by adding phosphoric acid. After neutralization process, the washing process of biodiesel was started. During the washing process, gentle agitation is required to avoid the emulsion. The wash water layer was drained off from the bottom of the washing tank. The washing process was repeated two to four times. After the washing process, it was required to measure the pH of the biodiesel layer. When the pH of the biodiesel layer reached 7, the washing process was completed. After that, the biodiesel layer was sent to the sand filtration tank. After filtration, biodiesel was obtained as a clear amber-yellow liquid with a viscosity similar to that of petrodiesel.	
5	b	**Describe the production of fuel from waste plastic.** METHODOLOGY A) Pyrolysis Pyrolysis is generally defined as the controlled heating of a material in the absence of oxygen. In plasticsPyrolysis, the macromolecular structures of polymers are broken down into smaller molecules or oligomersand sometimes monomer units. B) Thermal Pyrolysis of Polyolefin The non-catalytic or thermal Pyrolysis of polyolefin is a high energy, endothermic process requiring temperatures of at least 350–500 °C. MAIN DEVICES USED IN THE PROCESS	1 mark

		A) Condenser It cools the entire heated vapour coming out of the reactor. It has an inlet and an outlet for cold water to run through its outer area. This is used for cooling of the vapour. The gaseous hydrocarbons at a temperature of about 350°C are condensed to about 30 – 35°C. B) Reactor It is a stainless steel tube of length 300mm, internal diameter 225mm, outer diameter 230mm sealed at one end and an outlet tube at the other end. The reactor is placed under the LPG burner for external heating with the raw material inside. The reactor is made with the following: stainless steel, mild steel and clay for lagging. The reactor is heated to a temperature of about 450°C and more. C) Process Description Thermal cracking process without catalyst was used in converting waste plastic into liquid fuel. Two types of waste plastic are selected for this particular experiment. By weight 50% of each Low density polyethylene and polypropylene was selected for the experiment. Bothwaste plastic are solid hard form. Collected waste plastic was cleaned using liquid soap and water. During waste plastics are cleaned is cerates waste water. This waste water is purified for reuse using waste watertreatment process. Washed waste plastics are cut into 3-5 cm size to fit into the reactor conservatively. For experimental purpose we used 600gm sample 300gm of PP and 300gm of LDPE. A vertical steel reactor used for thermal cracking and temperature used ranges from100° C to 400° C. When temperature is increased to 270° C liquid slurry turns into vapour and the vapour then passes through a	2 marks 1mark

		condenser unit. At the end we collect liquid fuel. Between 100º C and250º C around 20 -30% of the fuelis collected and then when raised to 325º C the next 40% is collected and finally when held at 400º C the yield is fully completed. During the thermal cracking process plastic portions are not broken down immediately because plastics have short chain hydrocarbon to long chain hydrocarbon. 1st stage of heat applied breaks down only the short chain hydrocarbon. When temperature profile is increased the plastic carbon-carbon bond breakdown slowly. As thetemperature is increased the long chains are breakdown step by step. During in this thermal cracking process some light gas such as methane, ethane, propane andbutane are produced. METHOD AND METHODOLOGY Following two major methods are used to converting plastic wastes into useful products such as a fuels A.Thermal pyrolysis B.Catalytic pyrolysis A. Thermal pyrolysis The non-catalytic or thermal pyrolysis of plastic is a high energy, endothermic process requiring temperatures of at least 350° C–500° C. Thermal cracking or Pyrolysis, involves he degradation of the polymeric materials by heating in the absence of oxygen [1]. The process is usually conducted at temperatures between 350° C and 500° C and results in the formation of a carbonized char (solid residues) and a volatile B. Catalytic pyrolysis Addition of catalyst enhances the conversion and fuel quality. As compared to the purely thermal pyrolysis, the addition of	2 marks

		catalyst in pyrolysis. Significantly lowers pyrolysis temperatures and time. A significant reduction in the degradation temperature and reaction time [1] under catalytic conditions results in an increase in the conversion rates for a wide range of polymers at much lower temperatures than with thermal pyrolysis. Narrows and provides better control over the hydrocarbon products distribution in Low density polyethylene (LDPE), High density polyethylene (HDPE), polypropylene [5] and polystyrene pyrolysis. While thermal pyrolysis, results in a broad range of hydrocarbons ranging from C5 to C28, the selectivity of products in the gasoline range (C5, C12) are much more enhanced by the presence of catalysts. Again, oils obtained by catalytic pyrolysis contain less olefins and more branched hydrocarbon and aromatic content. Increases the gaseous product yields. Under similar temperatures and reaction times, a much higher gaseous product yield is observed in the presence of a catalyst for plastic wastes [3].In this papers going use catalytic pyrolysis method to convert waste plastic into bio fuel . mainly two catalyst are used such as dry ash powder and dry wood powder. Dry ash powder mainly consists of carbon content that accelerate the chemical reaction and dry powder helps to catch the fire easily and enhance the conversion of plastic waste into bio fuel compounds.	
5	c	**List environmental benefits of bioenergy. Explain how it is renewable.** **Environmental benefits of bioenergy –** 1. Emits little of no net greenhouse gas emissions. 2. Is a useful way of maintaining waste disposal for matter that would otherwise be debris. 3. Has well-established technology that's able to deliver reliable energy.	½ mark each for any 6

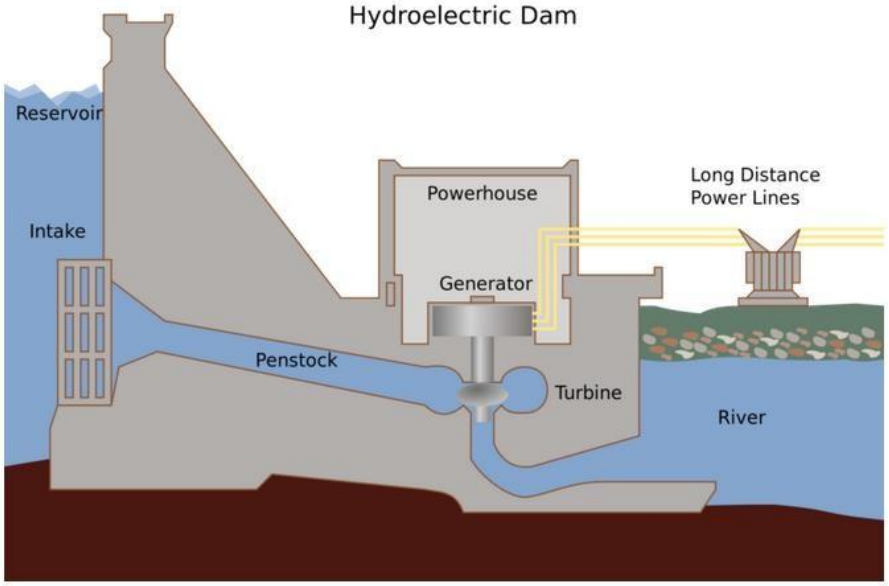
		4. Can be stored with minimal energy loss. 5. Is plentiful wherever there are agricultural cropos and forestry. 6. Can help to stabilize soils ,improve ,soil fertility and reduce erosion. 7. And can generate both heat and electricity in a cogeneration po0wer plant. 8. Biomass used as a fuel reduces need for fossil fuels for the production of heat , steam ,and electricity for residential , industrial and agricultural use. 9. Biomass is always available and van be produced as a renewable resource. **As a renewable source –** ▪ **Biomass is always and widely available as a renewable source of energy.** The organic materials used to produce biomass are infinite, since our society consistently produces waste such as garbage, wood and manure. ▪ **It is carbon neutral.** As a natural part of photosynthesis, biomass fuels only release the same amount of carbon into the atmosphere as was absorbed by plants in the course of their life cycle. ▪ **It reduces the overreliance of fossil fuels.** ▪ Not only is there is a limited supply of fossil fuels, but fossil fuels come with environmental baggage, including the release of large amounts of carbon dioxide into the atmosphere and the pollutants that result from removal, transportation and production. ▪ **Is less expensive than fossil fuels.** ▪ While fossil fuel production requires a heavy outlay of capital, such as	1 mark each for any 3

		oil drills, gas pipelines and fuel collection, biomass technology is much cheaper. Manufacturers and producers are able to generate higher profits from a lower output. ▪ **Biomass production adds a revenue source for manufacturers.** Producers of waste can add value by channeling their garbage to create a more profitable use in the form biomass energy. ▪ **Less garbage in landfills.** By burning solid waste, the amount of garbage dumped in landfills is reduced by 60 to 90 percent, and reduces the cost of landfill disposal and amount of land required for landfill.	
6		**Attempt any TWO of the following**	**12**
6	a	**Write concept and principle used in micro hydro power plant.** **Concept –** **Hydropower** plants capture the energy of falling water to generate electricity. A turbine converts the kinetic energy of falling water into mechanical energy. Then a generator converts the mechanical energy from the turbine into electrical energy. Although there are several ways to harness the moving water to produce energy, run-of-the-river systems, which do not require large storage reservoirs, are often used for microhydro, and sometimes for small-scale hydro, projects. For run-of-the-river hydro projects, a portion of a river's water is diverted to a channel, pipeline, or pressurized pipeline (penstock) that delivers it to a waterwheel or turbine. The moving water rotates the wheel or turbine, which spins a shaft. The motion of the shaft can be used for mechanical processes, such as pumping water, or it can be used to power an alternator or generator to generate electricity.	2 marks 2 marks

		Determining head Head is the vertical distance those waterfalls. It's usually measured in feet, meters, or units of pressure. Head also is a function of the characteristics of the channel or pipe through which it flows. Most small hydropower sites are categorized as low or high head. The higher the head the better because you'll need less water to produce a given amount of power, and you can use smaller, less expensive equipment. Low head refers to a change in elevation of less than 10 feet (3meters). A vertical drop of less than 2 feet (0.6 meters) will probably make a small-scale hydroelectric system unfeasible. However, for extremely small power generation amounts, a flowing stream with as little as 13 inches of water can support a submersible turbine. **Principle** – ▪ The water turbine changes the kinetic energy of the falling water into mechanical energy at the turbine shaft i.e. falling water spins the water turbine. ▪ The turbine drives the generator and converts mechanical energy into electrical energy.	2 marks
6	b	**Describe construction and working of high head micro hydro plant.** **Construction of hydroelectric power plant** **Dam and Reservoir:** The dam is constructed on a large river in hilly areas to ensure sufficient water storage at height. The dam forms a large reservoir behind it. The height of water level (called as water head) in the reservoir determines how much of potential energy is stored in it. **Intake gate or Control Gate:** Water from the reservoir is allowed to flow through the penstock to the turbine. The amount of water which is to be	2 marks

		released in the penstock can be controlled by a control gate. When the control gate is fully opened, maximum amount of water is released through the penstock. **Penstock:** A penstock is a huge steel pipe which carries water from the reservoir to the turbine. Potential energy of the water is converted into kinetic energy as it flows down through the penstock due to gravity. **Water Turbine:** Water from the penstock is taken into the water turbine. The turbine is mechanically coupled to an electric generator. Kinetic energy of the water drives the turbine and consequently the generator gets driven. There are two main types of water turbine; (i) Impulse turbine and (ii) Reaction turbine. Impulse turbines are used for large heads and reaction turbines are used for low and medium heads. **Impulse Turbines** Impulse turbines, which have the least complex design, are most commonly used for high-head microhydro systems. They rely on the velocity of water to move the turbine wheel, which is called the runner. The most common types of impulse turbines include the Pelton wheel and the Turgo wheel. **Reaction Turbines** Reaction turbines, which are highly efficient, depend on pressure rather than velocity to produce energy. All blades of the reaction turbine maintain constant contact with the water. These turbines are often used in large-scale hydropower sites.Because of their complexity and high cost, reaction turbines aren't usually used for microhydropower projects.	

		Generator: A generator is mounted in the power house and it is mechanically coupled to the turbine shaft. When the turbine blades are rotated, it drives the generator and electricity is generated which is then stepped up with the help of a transformer for the transmission purpose. **Surge Tank:** Surge tanks are usually provided in high or medium head power plants when considerably long penstock is required. A surge tank is a small reservoir or tank which is open at the top. It is fitted between the reservoir and the power house. The water level in the surge tank rises or falls to reduce the pressure swings in the penstock. When there is sudden reduction in load on the turbine, the governor closes the gates of the turbine to reduce the water flow. This causes pressure to increase abnormally in the penstock. This is prevented by using a surge tank, in which the water level rises to reduce the pressure. On the other hand, the **surge tank** provides excess water needed when the gates are suddenly opened to meet the increased load demand. **Electrical equipment:** The electrical equipment of a hydro electric power station includes alternators, transformers, circuit breakers and other switching and protective devices. **Diagram** -	



2 mark

Working of hydro power plant

- In Hydropower plant, dam acts as a strong wall to get the water level high in the reservoir, thus increasing its potential energy. Height difference in the level of reservoir and penstock, is the main reason behind all the pressure force that would strike the turbine and thus generate the required power.
- Once the control gates are opened the water through penstock travel to the turbine. Main reason behind having a surge tank is to prevent penstock from water hammering. It's a really very important part as, we have a valve just before the turbine which control the flow of water entering the turbine according to the load at the turbine.
- But the opening and closing of this valve is controlled directly by the governor action. Governor acts according to the load at the turbine. So

2 marks

		as the load at the turbine decreases gates slam shut in a short period of time. This would cause pressure to rise in penstock, thus could destroy penstock, but due to surge tank this pressure is compensated thus solving the problem. Surge tank also helps to cover up the air gap when load on the turbine increases instantly. It feed water to keep the flow of water striking turbine consistent and smooth, thus preventing the fluctuations in power output. ▪ Trash rack is there to remove all the impurities from the water going to turbine. It reduces the wear and tear of the turbine thus increasing the turbine life. ▪ Water strikes the turbine blades, converting the pressure energy of water into mechanical energy, which is further gets converted into electrical energy by generator. This voltage of the electricity is increased with step-up transformer and we are all set to transfer this high voltage electricity to nearest power grid through transmission lines.	
6	c	**Explain necessity of routine maintenance of micro hydro power plant. Write its procedure.** **Necessity -** In order to operate micro-hydro power plants in good condition for a long period, waterway facilities, electric equipment, transmission and distribution lines should be maintained adequately. Operators must try to observe even small troubles and prevent accidents of facilities. For this purpose, daily checks and periodic inspections are essential and recording and keeping of those data are also important. Though items and frequency of checks and inspections should be decided considering conditions of facilities and ways	3

		of use, general maintenance of micro-hydro power plants is as follows: Daily checks : In order to check if there is anything strange at waterway facilities, electric equipment, transmission and distribution lines, operators conduct daily checks along the course that has been fixed in advance. Operators must record results of checks and take measures if necessary. **Procedure of routine maintenance of micro hydro power plant –** • Turbine functional checks and inspection. • Turbine bearing lubrication and inspection. • Gearbox inspection. • Gearbox oil condition analysis and oil changes. • Gearbox bearing inspection and lubrication. • Drive belt inspection and replacement. • Drive coupling inspection. • Generator inspection. • Generator bearing inspection and lubrication. • Hydraulic system inspection. • Hydraulic system oil condition analysis and oil changes. • Check all sensors operate correctly. • Check controller functions correctly. • Inspection of intake area, impounding structures, pipeline, sluice(s).	3