MODEL ANSWER

WINTER– 2017 EXAMINATION

SUBJECT TITLE: RENEWABLE ENERGY SOURCES AND MANAGEMENT Subject Code: 17611

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	Sub Q.N.	Answer	Marking Scheme
Q 1	a	**(Two marks for advantages and limitations each)** **Advantages of renewable Energy sources** 1. These energy sources are sustainable and will never exhaust 2. It is available in abundance. 3. It has low operating and maintenance cost. 4. No fossil fuels are needed. No elaborated arrangements are required for transportation, handling and storage of fuels as needed in conventional power plants. 5. It can directly be converted into electrical energy using photovoltaic cells. 6. These energy sources produce no waste products, so it has no impact on environment. It is pollution free. **Limitations of renewable Energy sources** 1. It is dilute source of energy. 2. High initial cost. 3. It relies on the weather for its source of power. 4. It involves high cost of storage of energy. 5. Renewable energy technologies are still significantly new to the market,	

meaning, they still lack the much-needed efficiency

Q 1 **b**

Classification of renewable energy sources (½ mark for each source)

1. Wind power
2. Biomass
3. Solar applications of energy
4. Hydrogen
5. Fuel cells
6. Bio fuels
7. Bio gas
8. Ocean energy

Q 1 **c**

Solar distillation: **(Explanation – 2 marks, Figure – 2 marks)**

Figure shows various components of conventional double slope type solar distillation system. It is a air tight basin usually made up of concrete or special fiber with a transparent cover to accept radiation from the sun.

The inner surface of solar still is blackened to absorb maximum solar radiation. The blackened surface is known as basin liner.

The saline water is taken into basin for purification. The depth of the water is around 5 to 10 cms. Solar radiations after going through the still kept absorb by the blackened surface of the basin and thus temperature of water increases. Evaporated water increases the percentage of moisture which later on gets condensed on the cooler underside of the glass and then it is collected by means of condensate channel. in this way with the use of solar energy distillation process is completed.

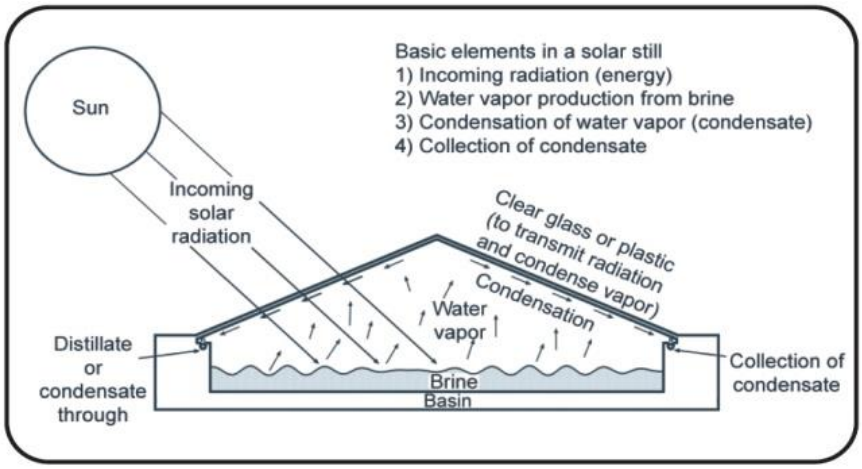
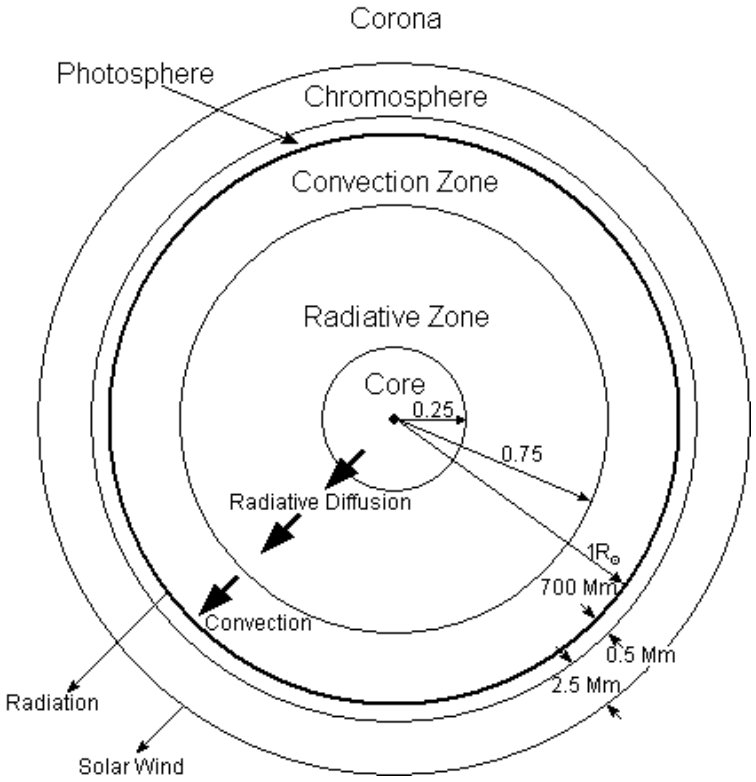


Fig- **Solar distillation**

Q 1	**d**	**Boiler efficiency for liquid fuels is calculated as (2 marks each)** η = ms(h-hf) / mf x C.V. Where ms = rate of steam generated in kg/hr h = specific enthalpy of steam KJ / kg hf = specific enthalpy of feed water KJ / kg mf = rate of fuel consumed in kg/hr C.V. = calorific value of fuel KJ / kg **Boiler efficiency for gaseous fuels is calculated as** η = ms(h-hf) / Vf x C.V. Where ms = rate of steam generated in kg/hr h = specific enthalpy of steam KJ / kg hf = specific enthalpy of feed water KJ / kg Vf = rate of fuel consumed in m3/hr C.V. = calorific value of fuel KJ / kg **Furnace efficiency is calculated as** η = heat utilized in stock / heat input in fuel	
Q 1	**e**	**Detailed Energy Audit Methodology**: It is a comprehensive analysis of an energy project and offers the accurate estimate of energy savings and cost. It covers the detailed study of present energy consumption, the use of energy for various processes with calculations of energy efficiency and to evaluate the improvements which can be carried out in its energy use. Detailed audit finally recommends the energy conservation proposals with cost of investment needed. It also presents the detailed study of expected savings in energy cost. The detailed energy audit report consists of the following : 1. Details about plant 2. Description of production processes involved 3. Description of energy and utility system 4. Detailed process flow diagram and energy 5. Calculation of energy efficiency and process systems 6. Recommendations for energy conservation	

Q 1	**f**	The effective wind velocity produces the total force acting on the blade section called aerodynamic force. It is proportional to the kinetic energy of stream and the projected area of blading. The resultant force can be resolved into two components as : **Lift:** FL which is normal to the direction of approach velocity. It is responsible for an aeroplane to maintain its lift. It is caused due to unbalanced pressure distribution over aerofoil surface. **Drag**: FD which is parallel to the direction of approach velocity. It represents the friction forces. Lift is useful component which gives rotation to the turbine. **Importance**- Lift is the useful component which gives rotation to the turbine. These factors FL and FD are related by their coefficients called lift coefficient CL and the drag coefficient CD.	
Q 1	**g**	**Classifications of Wind mill : : (Any four) 1 mark each** **a) According to their axis of rotation** (1) Horizontal axis wind mill (2) Vertical axis wind mill **b) According to size of capacity** 1) Micro size 2) Small size 3) Medium size 4) Large size **c) According to applications** 1) interconnection with utility grid 2) connected to power backup 3) pumping windmill 4) grain grinding windmill **d) Based on type of rotor** 1) Propeler type 2) Multiple blade type 3) Savonius type 4) Darrieus type	

Q 2	a	**Structure of sun : (Explanation – 3 marks, Figure – 5 marks)**	

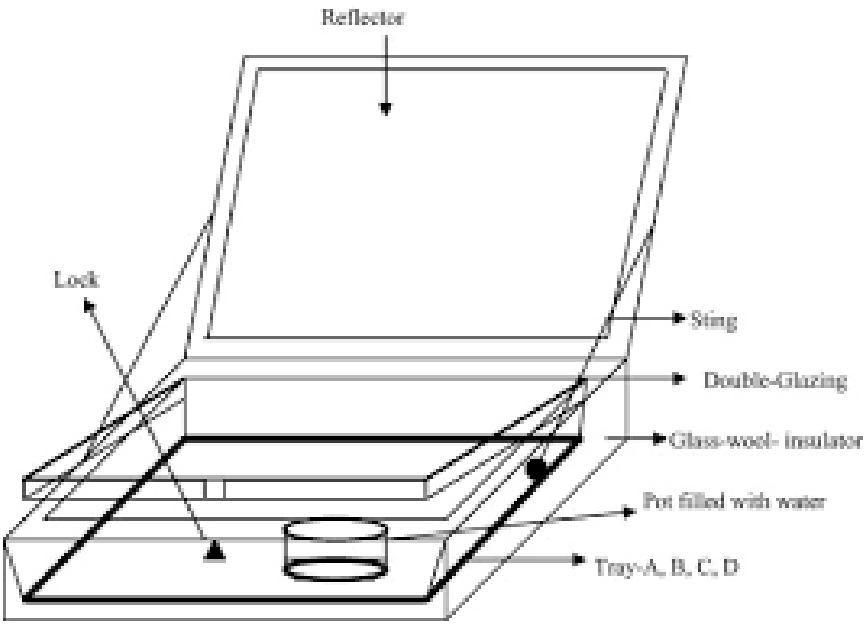


It consists mostly of hydrogen (90%) and helium (10%). The energy production takes place in the core. Its temperature is 1.5×10^7 K in the middle and 8×10^6 K at the border. The energy from the core passes through the mantle of the Sun by radioactive diffusion. In the outer regions the energy is transported by convection. This convection zone stretches from $0.8R_\odot$ to the Sun's border. The change in energy transportation is due to the lower transparency of the convection zone. The convection takes place in 2 (possibly 3) layers. The top layer has a convection cell size of 1 Mm. As this cells form a granular pattern visible on the Sun's surface the layer is called the granulation. Below it is the super granulation. Its cells have a diameter of 30 Mm.

Above the convection zone is the photosphere. This region is only 0.5 Mm thick and emits most of the Sun's light. The temperature is merely 5000 K.
The chromosphere lies above the photosphere. It is 2.5 Mm high. In the chromosphere the temperature rises sharply to 10^6 K. The cause of this increase is unclear. It is a major topic of solar studies.

Outside the chromosphere is the Sun's corona. It expands several solar radii from the Sun. The coronal gas is about 10^6 K and has a very low density. From Earth the corona is only visible

Q 2	b (i)	**Criteria for site selection of small hydro electric power plant** **(1/2 mark for each, any eight)** 1.Water availability and method of storage 2.Availability of head 3.Distance of power station from power demand centre 4.Availability of construction materials 5.Access to site, 6.Availability of transport facilities etc 7.Availability of labour power 8.Heavy rain fall area	
Q 2	b(ii)	**Need to switch over alternate energy sources because of the following reasons** **(Any four reasons – 1 mark each)** 1. The supply of crude oil will fail to meet increasing demand. 2. Demand for energy is continuously growing , to meet this alternate energy source is essential 3. Coal reservoirs are unable to fulfill the energy demand 4. Nuclear energy, hydroelectric energy, wind energy, solar energy sources are utilized but they also unable to meet energy demand. Thus there is need to switch over alternate energy sources like Municipal and industrial wastes Biomass, Biogas plants, improved wood stoves, solar water heaters solar cookers, solar lanterns can be used at large	
Q 2	c (i)	**Following are the uses of the instruments: (1 mark each)** 1. **Infrared thermometer** : To measure temperature of heat source without coming in contact with other surface 2. **Fyrite** : To measure the volume of O2 , CO2 and other gases 3. **Manometer**: To measure the pressure 4. **Lux meter**: To measure illumination level	

Q 2	**c (ii)**	**Non solar renewable energy sources** : Energy sources which are not obtained directly from sunlight but are obtained indirectly from sun. Ex: Hydro and wind power, biomass ,geothermal , tidal , ocean energy , etc **(2 marks each)**	
Q 3	**a**	A box type solar cooker consists of an insulated box with a transparent cover made of glass or plastic. Usually the box also includes one or more adjustable external flat reflectors ("boosters") in order to enhance solar radiation into the cooker. The operation of a solar box cooker is based on the greenhouse effect. The maximum temperature is about 150 C. **(Explanation – 2 marks, Figure – 2 marks)**  **Fig- box type solar cooker**	
Q 3	**b**	**Thermal insulation: (Explanation – 2 marks, Examples– 2 marks)** The term thermal insulation can refer to materials used to reduce rate of heat transfer or the methods and processes used to reduce heat transfer. Heat energy can be transferred by conduction, convection, radiation or when undergoing a phase change. The flow of heat can be retarded by addressing these mechanisms. Names of Thermal insulating materials: 1. Fiberglass 2. Mineral Wool 3. Cellulose. 4. Polyurethane Foam.	

5. Polystyrene.

Q 3 c : **(Explanation – 2 marks, Policies – 2 marks)**

OPEC is an Organization of the Petroleum Exploring Countries . It was founded in 1960.

- OPEC is an international organization whose mission is to co-ordinate the policies of oil producing countries.The goal is to secure a steady income to member states and to secure supply of oil to customers.
- The head quarter is in Gineva , switerland, bfore moving to Vienna, Austria.

Membersof OPEC are Algeria, Angola, Equador, Iran , Iraq, Kuwait, Libiya, Nigeria, Quatar, Saudi Arabia, UAE, and venezuala.

POLICIES OF OPEC

1. To co-ordinate the policies of the oil producing countries.
2. To control International oil prices by varying the oil production by the organisation.
3. To secure steady income to members of the organisation.

Q 3 d

i. **Solar Zenith angle θz**: If a vertical line is drawn to this horizontal plane at its centre , The line joining Sun and the centre of the plane is called Solar Zenith angle or it is the angle between sun rays and perpendicular (normal) to the horizontal plane.

ii. **Declination angle (δ)** : It is the angle between a line extending from the centre of the sun to the centre of the earth and the projection of this line upon the earth's equatorial plane**. (Each definition – 2 marks)**

Q 3 e

Fuel cells – Fuel cell is an emerging technology. It is an electrochemical device that continuously converts the chemical energy of the fuel directly into electricity and heat without intermediate state of combustion.

Fuel cells are generally categorized by their electrolyte. The material sandwiched between two element determine the optimum temperature and the fuel used to generate the electricity.

Q 3 f

Photosynthesis : It is the process in which solar energy is converted into biomass energy. Photosynthesis process occurs only in green plants. It is the process of combining CO2 from the atmosphere with water in the presence of light energy to produce carbohydrates and oxygen.

The photosynthesis process is complex but overall photosynthesis process can be represented by the following process

$$6CO2 + 6H2O + \text{light energy} = C6H12O6 + 6\ O2$$

Total energy stored in the photosynthesis process is about 4500 kJ

Q 4 **a**

Photovoltaic energy conversion: When photon is absorbed, its energy is given to an electron in the crystal lattice. The energy given to this valence bond excites it into the conduction band.

(Explanation – 2 marks, Figure – 2 marks)

Photovoltaic cell: A solar cell or photovoltaic cell is a device that converts solar energy into electricity by the photovoltaic effect. Photons in sunlight hit the solar panel and are absorbed by semiconducting materials such as silicon.

Electricity can be produced by solar cells whose principal component consists of a semiconductor that is typically made of silicon. Solar cells are often electrically connected and encapsulated as a module often has a sheet of glass. To make practical use of solar generated energy the electricity is most often fed into electricity grid using inverters.

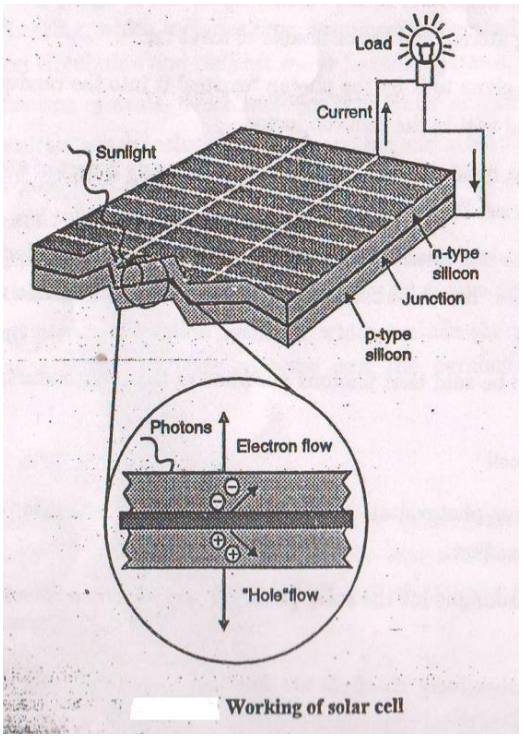


Fig- Photovoltaic energy conversion

Q 4 **b**

Solar Space heating by passive method.

(02 marks for sketch, 02 marks for explanation)

Space heating: A solar space heating can consist of a passive system, an active system or combination of both. Passive systems are typically less costly and less complex than active system. Passive solar space heating takes advantage of warmth from the sun through design features such as large south facing windows and materials in the floors or walls that absorb warmth during the day. A sunspace or greenhouse is a good example of passive system for solar space heating

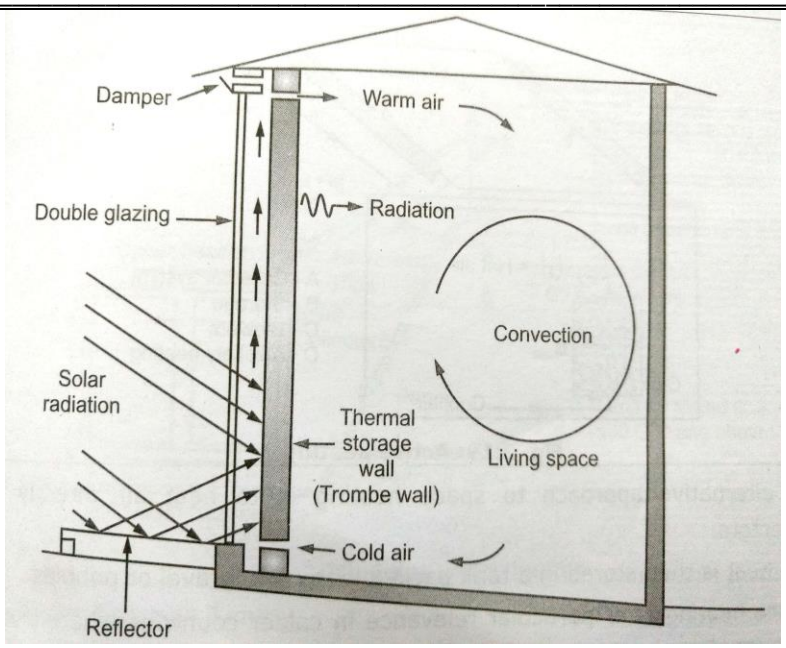


Fig- solar passive space heating system

The south facing thick wall called trombe wall is made of concrete, adobe, stone or composite of bricks, blocks and sand designed for thermal storage.in order to increase the absorption the outer surface is painted black. The entire south wall is covered by one or two sheets of glass or plastic sheet with some air gap between the wall and inner glazing. Solar radiation after penetration through the glazing is absorbed by the thermal storage wall. The air in the air gap glazing and the wall thus gets heated, rises up and enters the room through the upper vent while cool air from the room replaces it from the bottom went. The circulation of air continues till the wall goes on heating. Thus wall collect, stores and transfers the heat to the room. Heating can be adjusted by controlling the airflow through the inlet and outlet vents by shutters. With help of damper at the top of glazing allows the excess heat to outside when heating is not required.

Q4 **c**

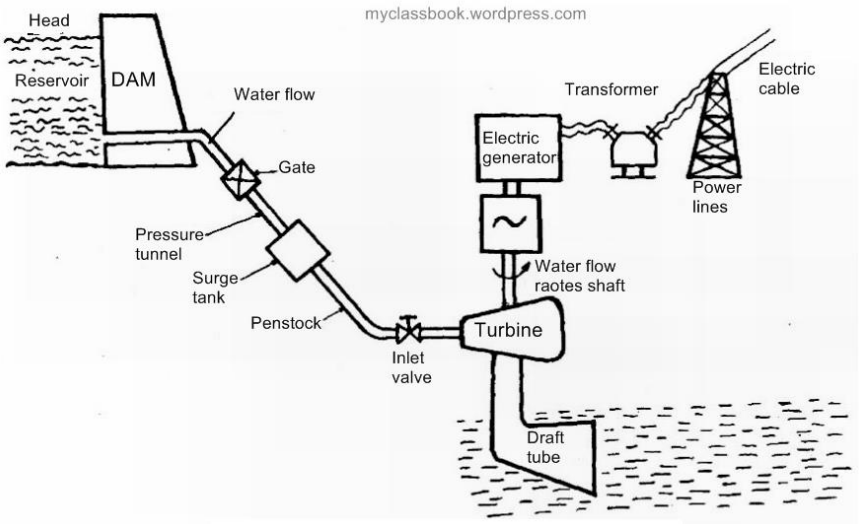


Fig- hydroelectric power plant

Q 4 d

Micro-hydel plant : Micro- hydel plants work under a head of 5 meters. Such low head plants can only be build in states of UP, HP and Arunachal Pradesh. These plants can be constructed in short time along a stream of the river. An existing mill-pond or other artificial reservoir is available and can be adapted for power production. In general, micro hydro systems are made up of a number of components. The most important include the intake where water is diverted from the natural stream, river, or perhaps a waterfall. An intake structure such as a catch box is required to screen out floating debris and fish, using a screen or array of bars to keep out large objects. The intake then tunnels water through a pipeline (penstock) to the powerhouse building containing a turbine.

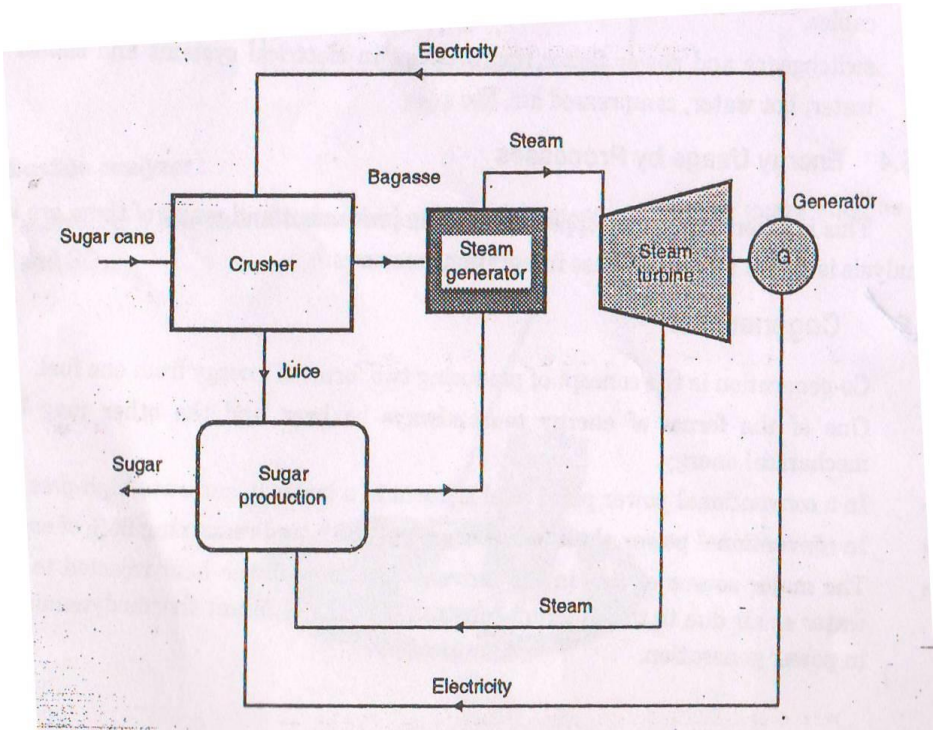
Axial flow bulb turbine and Axial flow tubular turbines are best suited for the micro hydel plants. : **(Explanation – 3 marks, Example – 1 mark)**

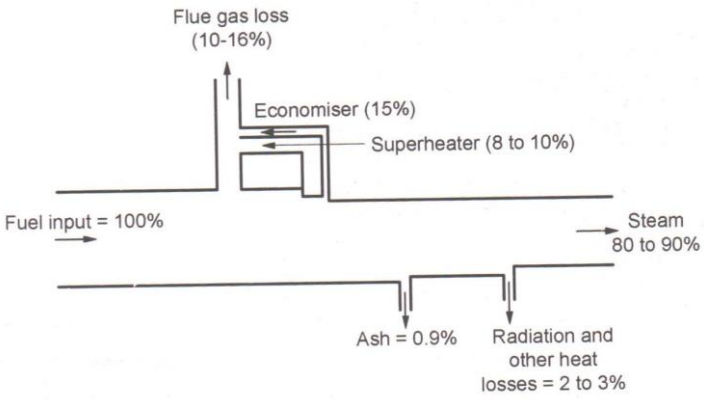
Q 4 e

Co-generation is procedure for generating electric power and useful heat in a single installation. The useful heat may be in the form of steam, hot water, or hot air. In the cogeneration system, a mechanical work is converted into electrical energy in an electric generator and the discharged heat, which would otherwise be dispersed to the environment, is utilized in an industrial process or in other ways. The net result is an overall increase in the efficiency of fuel utilization.

In sugar factory juice is extracted from cane and bagasse is burned to generate steam. The steam is sent to steam turbine to generate electricity. Extracted steam and low pressure steam from turbine is used in the process of sugar manufacturing

(Explanation – 2 marks, Figure – 2 marks)



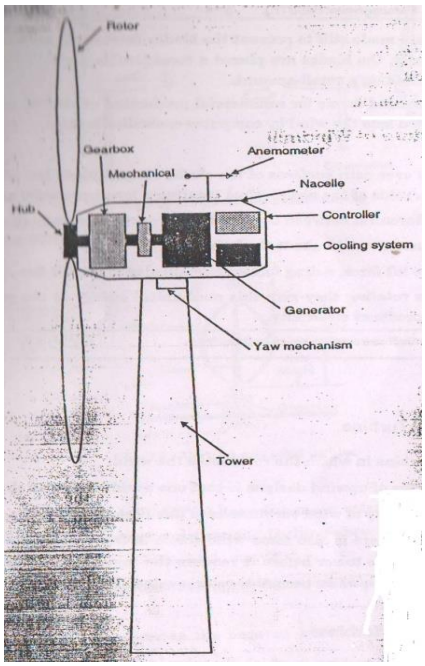
Q 4	f	**Sankey diagrams:** Sankey diagrams are a specific type of flow diagram in which the width of the arrows is shown proportionally to the flow quantity. They are typically used to visualize energy or material cost transfers between processes. They are also commonly used to visualize the energy accounts or material flow accounts on a regional or national level. Sankey diagrams put a visual emphasis on the major transfers or flows within a system. They are helpful in locating dominant contributions to an overall flow. Often, Sankey diagrams show conserved quantities within defined system boundaries, typically energy or mass, but they can also be used to show flows of non-conserved quantities such as energy. Sankey Diagrams drop their arrows when energy is being used. **Sankey diagram for boiler plant:** Boiler efficiency can be improved by using the heat in flue gases to superheat the steam in the super heater, to heat feed water in economizer and preheat in the air in preheater before discharged to the atmosphere through chimney.  **Sankey diagram for boiler plant (2 marks each)**	
Q 5	a	**Horizontal axis wind mill : (05 marks for components description and 03 marks for sketch)** **Wind mill**: Basic structure of windmill consists of the following components. i) Rotor blades: The rotor blades extract the wind energy and converts it into rotational form ii) Gearbox: It converts the rotational speed from low speed shaft and transforms it into faster rotation on the high speed shaft iii) Hub: It is the connection point for the rotor blades and low speed shaft	

iv) Mechanical brake: It is a disc brake used for repairs and maintenance of the wind mill.

v) Generator: It converts the rotational speed of high speed shaft to electrical energy

vi) Yaw mechanism. This mechanism keeps the rotor blades parallel to the flow of wind

vii) Anemometer and wind vane: They are the instruments for measuring wind speed



Basic structure of windmill

(1 mark each)

Q 5 b(i)

Bio-mass	Conventional Fuel
1.Bio-mass is an organic matter produced by plants .	1. Conventional fuels are coal, oil, gas and nuclear energy.
2. Non exhaustible	2. exhaustible
3. No pollution	3. Harmful pollutants released.
4.Solar radiation are used for photosynthesis process.	4. high energy density

(ii)

Solar Pump system : (Figure – 2 marks)

Major components of solar pumping system are (2 marks)

1. Solar panels- It is the basic power source of a solar pumping system. The basic element of the panel is the solar cell.

2. Charging and control circuit – Its function is to ensure that when the electricity produced by the solar panel is sufficiently high, it charges the battery.

3. Pumps- The most commonly used water pumps are centrifugal pumps.

4. Water storage system – The pump is running and pumping water to a storage tank.

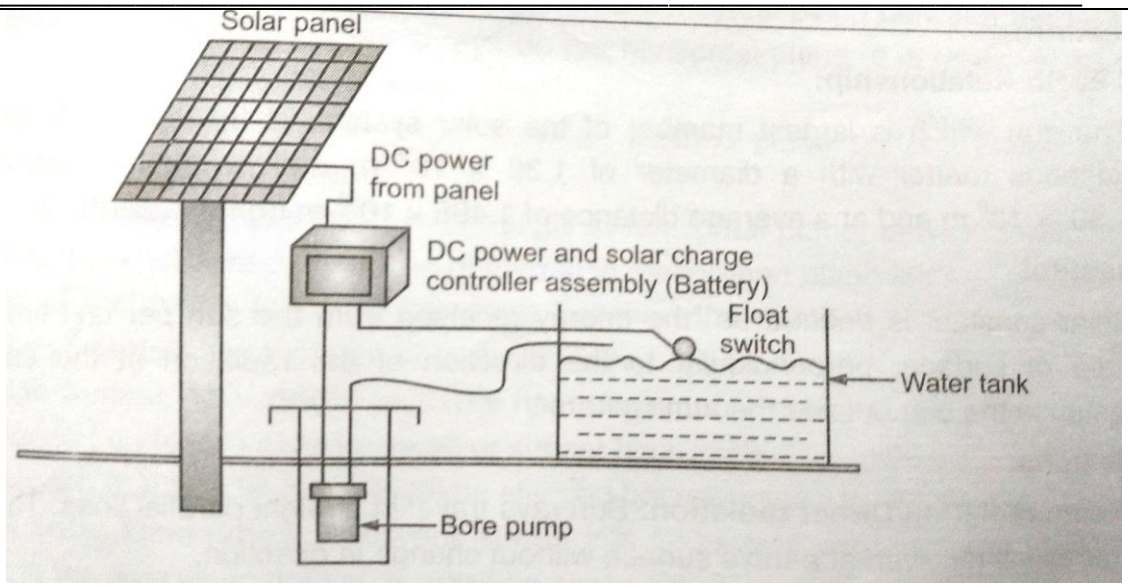


Fig- solar water pumping system

A solar water pumping system is an electrically driven pumping system. Electricity is produced by the sunlight emerging photovoltaic modules. When the sun energy falls on the solar cell, the cell produces DC current and for constant load solar charge controller is used. The DC electrical energy is stored in battery and battery is connected to pumping system.

5 c (i)

Advantages: (2 marks)

1. Cost per unit area is less
2. Requires less absorber area
3. High collection efficiency
4. Suitable for large power generation
5. Heat storage cost is lower
6. No antifreeze solutions are needed

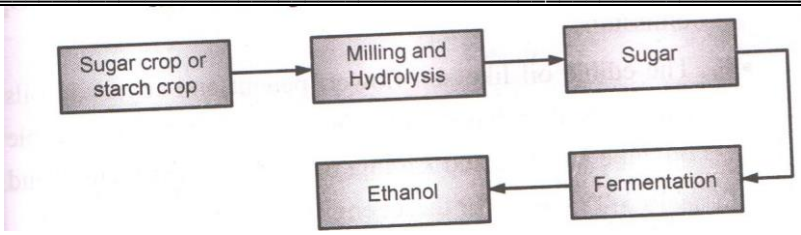
Limitations : (2 marks)

1. Needs tracking which increases cost
2. Diffuse radiations cannot be collected
3. Higher initial and maintenance cost

c(ii)

Production of Ethanol from sugarcane: (Explanation – 2 marks, Figure – 2 marks)

The Ethanol can be produced from sugarcane by fermentation. It can also be produced by cellosic biomass by its hydrolysis to convert into sugar and then by fermentation. This production of ethanol from cellulosic process is quite complex.



Production of Ethanol from sugarcane

Q 6 **a**

Solar cell: It converts solar energy into electrical energy without having to go through other thermal process. These are reliable, modular, durable and generally maintenance free

Solar module: When number of cells are combined , it forms solar module

Solar panel : When number of modules are connected , it forms a solar panel

Solar array : When number of solar panels are connected, it forms a solar array

Q 6 **b**

Working of Kaplan Turbine (Working – 2 marks, Figure – 2 marks)

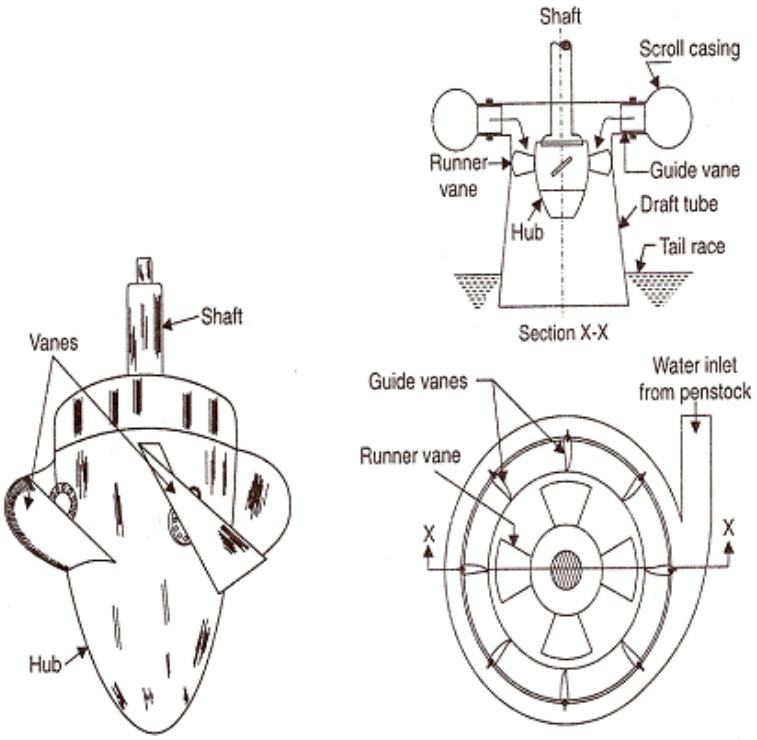


Fig- Kaplan Turbine

Q 6 **c**

WORKING OF KAPLAN TURBINE: The Kaplan turbine is an inward flow reaction turbine, which means that the working fluid changes pressure as it moves through the turbine and gives up its energy. The inlet is a scroll-shaped tube that wraps around the turbine's wicket gate. Water is directed tangentially, through the wicket gate, and spirals on to a propeller shaped runner, causing it to spin.

The outlet is a specially shaped draft tube that helps decelerate the water and recover kinetic energy.

The turbine does not need to be at the lowest point of water flow, as long as the draft tube remains full of water. A higher turbine location, however, increases the suction that is imparted on the turbine blades by the draft tube. The resulting pressure drop may lead to capitation.

Variable geometry of the wicket gate and turbine blades allows efficient operation for a range of flow conditions.

Pyranometer

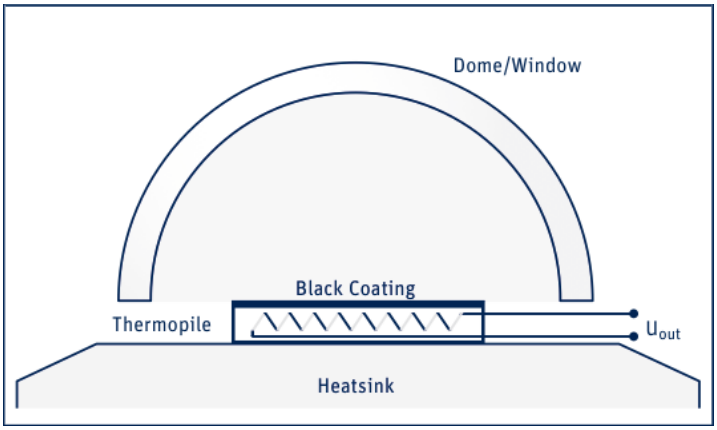


Fig- Pyranometer

The thermoelectric detection principle is used in Pyranometer, whereby incoming radiation is almost completely absorbed by a horizontal blackened surface, over a very wide wavelength range. The resulting increase of temperature is measured via thermocouples connected in series or series-parallel to make a thermopile. The active (hot) junctions are located beneath the blackened receiver surface and are heated by the radiation absorbed in the black coating. The passive (cold) junctions of the thermopile are in thermal contact with the Pyranometer housing, which serves as a heat-sink. More recent, higher performance, Pyranometer use a Peltier element. This is also thermoelectric, but the dissimilar metals of a thermocouple / thermopile are replaced by dissimilar semiconductors.

Q 6 d

Following are the various process used for conversion of biomass into energy (2 Marks)

1. Direct combustion
2. Thermo chemical conversion
   a. Gasification
   b. Pyrolysis
3. Biochemical Conversion
   a. Fermentation of biomass
   b. Anaerobic digestion of biomass

Anaerobic digestion: Anaerobic digestion is a biochemical process in which the particular kinds of bacteria digest biomass in an oxygen free environment. The process of anaerobic digestion occurs in a sequence of stages involving distinct types of bacteria.

Hydrolytic and fermentative bacteria first break down the carbohydrates, proteins and fats present in biomass feedstock into fatty acids, carbon dioxide, hydrogen, ammonia and sulfides. This stage is called hydrolysis. Next, acetogenic bacteria further digest the products of hydrolysis into acetic acid, hydrogen and carbon dioxide. Methanogenic bacteria then convert these products into biogas. The combustion of digester gas can supply useful energy in the form of hot air, hot water or steam. After filtering and drying, digester gas is suitable as a fuel for an I.C. engine, which combined with generator, can produce electricity.+ **(2 Marks)**

Q 6 e

Bio-diesel is a methyl or ethyl ester of fatty acids made from vegetable oils and from animal fat. These fuels either in pure form or blended with diesel can be used in diesel engines with or without modification in the engine respectively. **(2 Marks)**

Applications of Biodiesel (2 Marks)

- Biodiesel is used as fuel in diesel engine driven automobile vehicles like cars, trucks and buses. It is mixed in petroleum diesel in suitable proportion like B10 or B20 and used in engine.
- Biodiesel is used as fuel in Diesel railway engines. It is mixed in petroleum diesel in suitable proportion like B5 or B10 and used in engine.
- Biodiesel is used as an alternative fuel in oil fired boilers where conventionally furnace oil or diesel is used.
- Biodiesel is used as an alternative fuel in diesel engine pump sets used in farms.
- Biodiesel is used as an alternative fuel in diesel engine Generator sets used for electricity generation.
- Biodiesel is used as an alternative fuel in farm tractors used in farms.

Q 6	f	• **Gasification:** The gasification process in general involves the reaction of solid fuels with hot steam and air or oxygen and the subsequent production of gaseous fuel by partial oxidation. The figure explains the process of gasification of biofuel. **(2 Marks)** **Pyrolysis:** It is the heating of biomass in a closed vessel at temperatures in the range of 500 o C to 900 o C in absence of O2/ air or with steam. It produces solid, liquid and gases. This process can use all type of organic materials including plastic and rubbers. **(2 Marks)**	