MODEL ANSWER

SUMMER– 18 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.

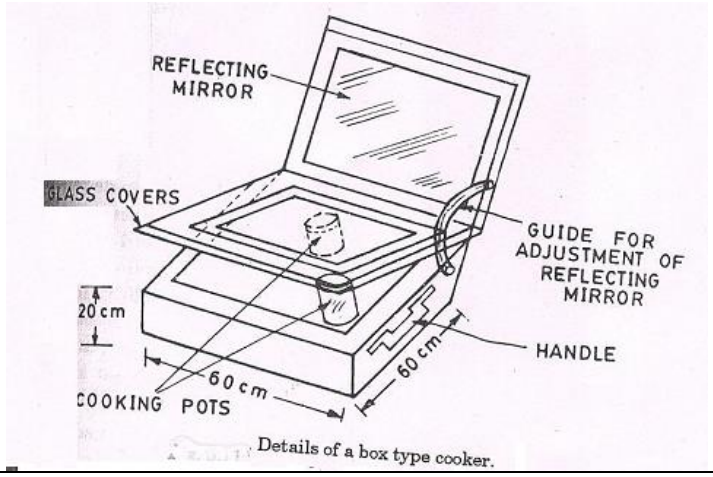
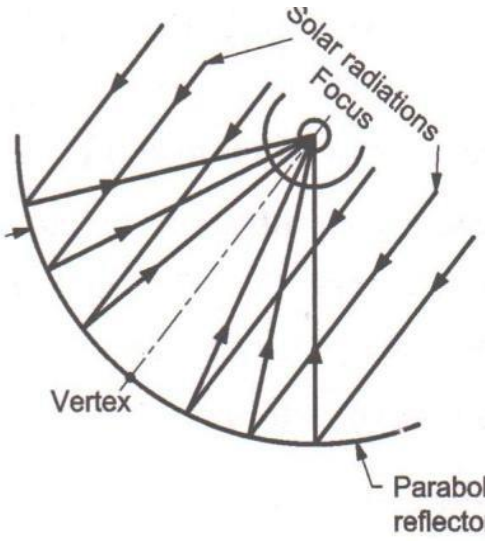
Q. No.	Sub Q. N.	Answer	Marking Scheme
1(A)	**a**	Classifications of Renewable energy sources : 1) Solar energy 2) Wind energy 3) Tidal energy 4) Geothermal energy 5) Bio mass energy	02
		Utilization of energy sources can be by direct and indirect methods Direct methods – Thermal and photovoltaic Indirect methods – Tidal, wind, biomass and ocean thermal energy	02
	b	 Details of a box type cooker.	02

Figure shows the box type solar cooker. The solar rays penetrate through the glass covers and absorbed by a blackened metal tray kept inside the solar box. Two glass covers are provided to again minimize the heat loss. The loss due to convection is minimized by making the box air tight by providing a rubber strip all rounds between the upper lid and the box. When the cooker is placed in the sun, the blackened surface starts absorbing sun rays and temperature inside the box starts rising. The blackened cooking pots get heat energy and food will be cooked in a period of time. — 02

c **Solar concentrating collector:-**

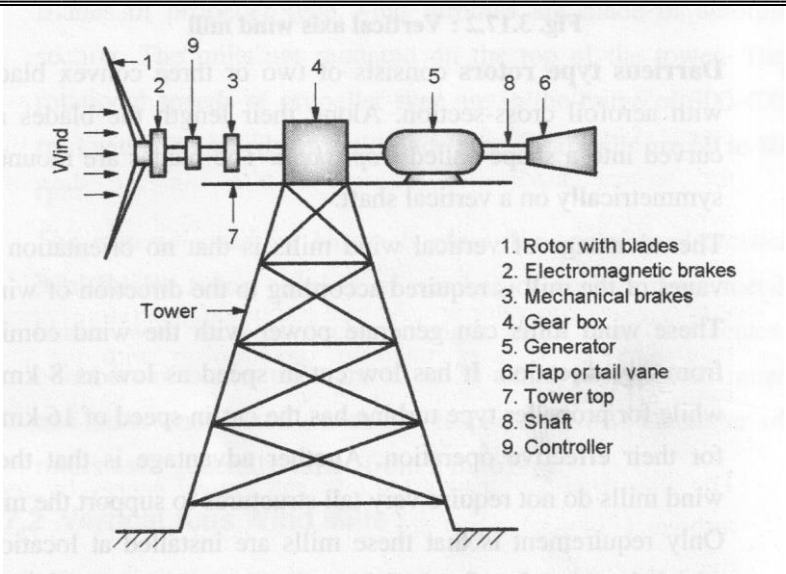
These concentrating collectors are used in which the absorber is placed along the focus axis. In this the collector pipe is used as an absorber with a selective coating. Parabolic reflectors are usually made of highly polished or silvered glass or of a film of aluminized plastic on affirm base. Instead of the reflector having a continuous form the reflector may be made of a large number of flat mirror strips on the parabolic firm base. — 02



Parabolic concentrating solar collector — 02

d **Components of power generating Horizontal axis wind turbine :**

i) **Rotor blades**: The rotor blades extract the wind energy and convert 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 — 02



02

Q. 1 B. **a.** **Need of orientation in concentrating type collectors**: In flat plate collectors solar direct and diffuse radiations without sun tracking are collected for heating. It causes the loss of energy during sunshine period since the solar radiations will not be normal to the surface and the temperature achieved are only 100 O C . For temperatures above these concentrating type collectors are needed. A cylindrical parabolic collector is oriented with its focal axis pointed either in the east-west or the north-south direction. In the east-west orientation the focal axis is horizontal while in the north-south orientation, the focal axis may be horizontal or inclined. Different methods for sun tracking :

03

i. The focal axis is east-west and horizontal
ii. The focal axis is north-south and horizontal
iii. The focal axis is north-south and inclined at a fixed angle equal to the latitude.

Describe any one method

b **Uses of Instruments:-**

03

1 **Lux meter**: To measure illumination level

2 **Pyranometer** : To measure global radiations

3 **Infrared thermometer** :- To measure temperature of heat source without coming in contact with other surface

01 M each

4 **Fuel efficiency monitor** :-

1. In this instrument the calorific value of the commonly used fuels are fed into microprocessor.
2. When this instrument measures the oxygen and temperature of the flue gas, it automatically calculates the efficiency of the combustion

		5. **Power analyser** :- 1. It is used for measuring electrical power.(kW) , 2. It is used for measuring power factor . 6. **Sunshine recorder** :- To measure the hours of bright sunshine in a day	
Q2	**a**	1) **Altitude angle (α):** It is defined as the angle between the central ray from the sun , and a horizontal plane containing the observer is the Solar altitude angle. At the Sunrise and Sunset the solar altitude angle(α) is zero. 2) **Zenith Angle** : If a vertical line is drawn to the horizontal plane at its centre the line joining sun and the centre of the plane will make an angle ɵ with this vertical . This angle is called the Zenith angle. 3) **Day length (td):** It is the time elapsed between sunrises to sunset. By knowing the values of sunrise and sunset hour angle, we can calculate the day length. 4) **Solar Azimuth angle** ( ):- It is the horizontal angle measured on plane from north to the projection of suns rays on this plane . 5) **Surface azimuth angle** :- ( ) : It is defined as the horizontal angle between the projection of the normal to the horizontal surface and the north south line. 6) **Local solar time** :-This is also called as Local Apparent Time (td) and can be calculated using various values of zenith angle . the time so calculated is called the Local Solar Time. 7) **Slope** : It is also called as tilt angle ( ) . The vertical angle between one edge of a surface and its projection on the horizontal plane is called the tilt angle . 8) **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.	**01 M each**
	b	**i) 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. **Factors affecting bio digestion: Following factors are affecting the biodigestion:** 1) pH or the hydrogen-ion concentration 2) temperature	02

		3) total solid content of the feed material 4) loading rate 5) seeding uniform feeding 6) Diameter to depth ratio 7) Carbon to nitrogen ratio 8) Nutrients 9) Retention time 10) Types of feed stock **ii) Comparison Wet and Dry fermentation : (Any four points – 1 M each)** **Dry fermentation** : Organic input remains stationary throughout process, eliminating moving parts and resulting in low system maintenance and repair costs Batch process and stationary system allow precise control over input removal ensuring maximum energy yield Closed loop liquid cycle following start-up, eliminating post-process waste water treatment needs No pre-treatment or sorting of inputs required prior to system loading, saving time and money for system operators Almost no limitations to inputs—over 3,000 inputs have been identified and researched BIOFerm™ system has low energy consumption, using only 5% of the energy generated for plant operation **Wet fermentation** System requires mechanical parts to circulate biomass in liquid holding tank, leading to increased maintenance and repair costs Liquid mixture causes premature removal of input before all organic matter has been digested, resulting in a loss of energy System requires additional liquid to allow fermentation, greatly increasing the amount of system waste water and costly post-process treatments Inputs require pre-treatment to prevent breakdown of mechanical parts as input is agitated and moved through system Input limited to “wet” waste streams .	02

c i) **Energy Audit**: An energy Audit is the first step in energy management programme. It shows how efficiently energy is being used and highlights opportunities for energy cost savings. It also shows ways to improve productivity. 02

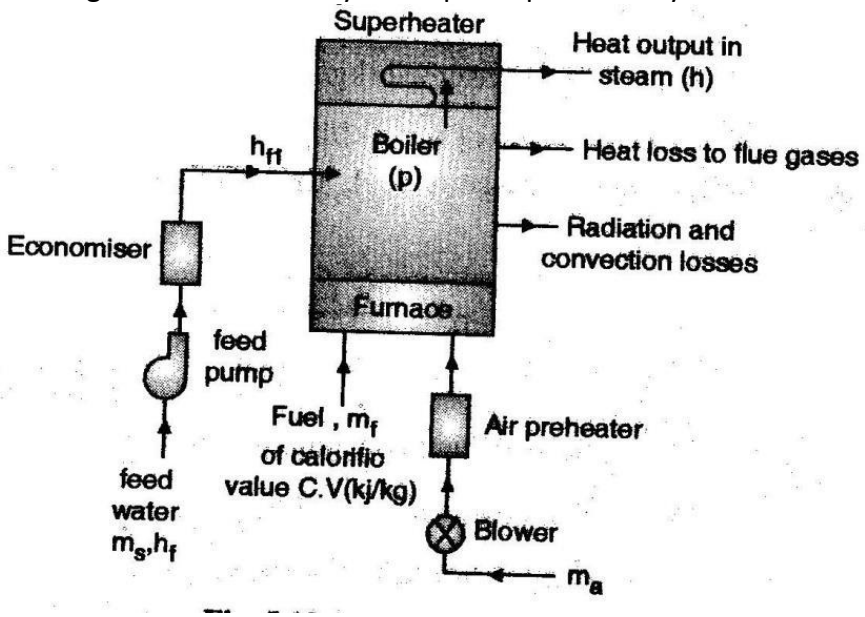


Figure shows energy audit in boilers 02

ii) Boiler efficiency for liquid fuels is calculated as

$$\eta = ms(h-hf) / mf \times C.V.$$

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

$$\eta = ms(h-hf) / Vf \times C.V.$$

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

04

Q. 3 **a.**

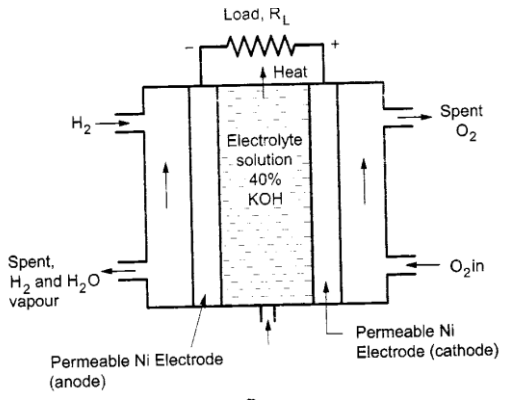
A fuel cell is defined as an electromechanical device that continuously converts the chemical energy of fuel into electricity and heat without combustion.

The main components of a fuel cell are

1. A fuel electrode (anode)
2. An oxidant electrode (cathode)
3. An electrolyte
4. Additional components are container, separators, sealings, fuel and oxidant supply etc.

The porous fuel electrode is anode and other porous oxidant electrode is cathode. These electrodes are separated by a porous gas barrier called separator.

The anode is supplied H2 gas as fuel at a certain pressure and the cathode is supplied o2 as oxidant at a pressure. These gases pass through the respective electrodes and bubble around through the electrolyte solution. The pores provide an opportunity to gases, electrodes and electrolyte to come in contact for their electrochemical reactions. The electrodes are connected through an external circuit as shown .



02

b **Selection criteria for wind power plant (Any four)**

Parameters of site selection of wind mill:

1) Availability of higher constant wind speed
2) Availability of wind at site through year
3) Altitude of the site
4) Availability of land
5) Connectivity to grid
6) Connectivity to the road
7) Easy access to locality/infrastructure
8) Ecology

02

04

c. **Classify hydroelectric power plant :-**

The classification according to Quantity of water available is

I) Run-off river plants without pondage
(ii) Run-off river plants with pondage
(iii) Reservoir Plants

The classification according to availability of water head is

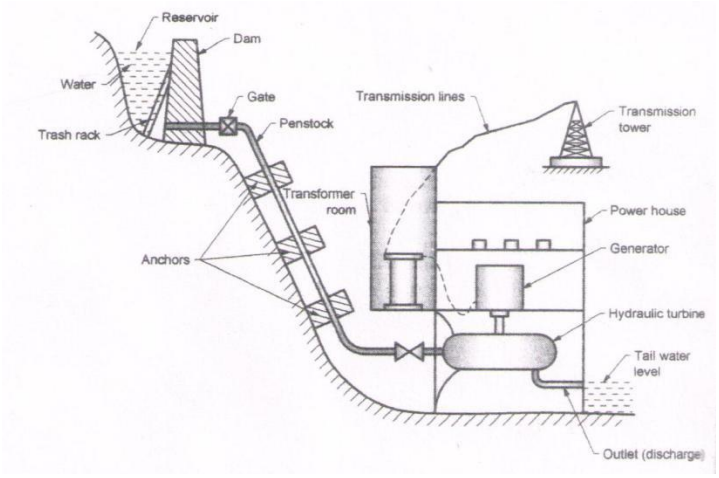
i) Low-Head (less than 30 meters) Hydro electric plants
(ii) Medium-head(30 meters – 300 meters) hydro electric plants
(iii) High-head hydro electric plants

The classification according to nature of load is

i) Base load plants
(ii) Peak load plants

02

Reservoir hydroelectric power plant:



A hydro electric power plant consists of the following :

1.Reservoir : used to store water during rainy season. This water is used to run the hydraulic turbine

2.Dam : It is a structure of considerable height built across the river. It provides working head of water for power plant

3.Gate : It is provided for controlling of flow of water from reservoir to turbine

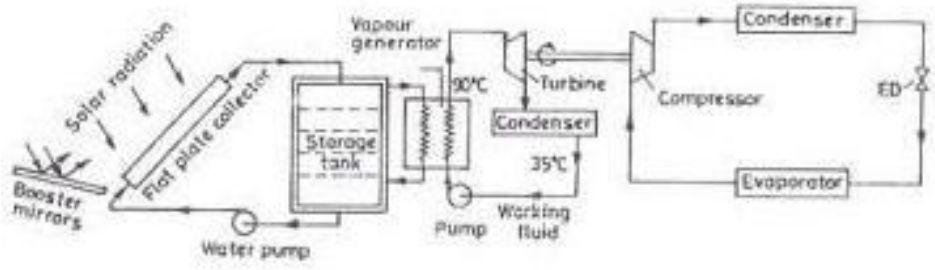
4.Waterway and penstock: Waterway carries water from the dm to the power house. It includes canal and penstock or tunnel

5.Hydraulic turbine: These are used to convert the kinetic energy of water into mechanical energy

02

d A Solar vapor compression refrigeration system is shown in figure. It consists of mainly solar collector and storage tank for heat exchange in the exchanger. The turbine power is used to run the compressor of usual VCR system.

It is to be noted that there is no requirement of external electrical power supply to the compressor as it is given by the turbine running on solar energy.



02

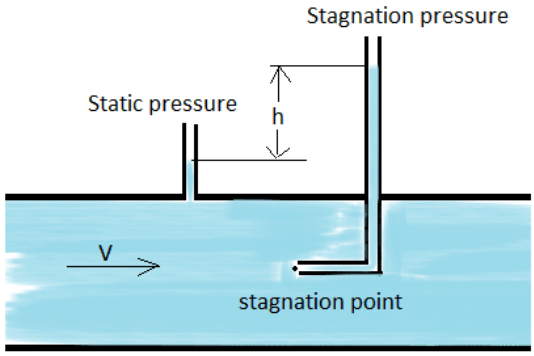
e Bio-energy Sources : — 02

Following are the bioenergy sources :

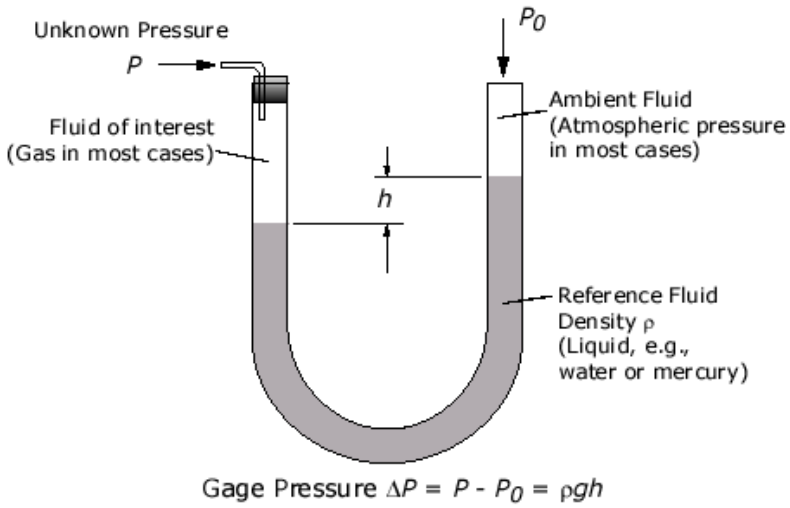
1. Energy plantation
2. Agricultural crops
3. Wood residues
4. Animal waste
5. Municipal solid waste
6. Land fill gas
7. Commercial and industrial waste

Commercial waste are the biomass derived from wastes e.g. municipal waste animal and human excreta, forest waste etc

f **Pitot tube** — 02



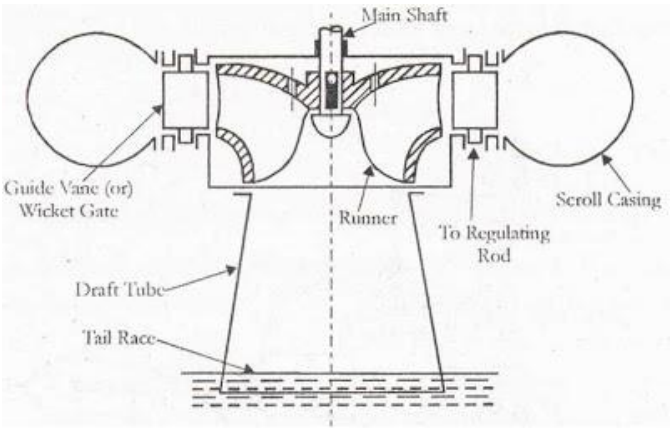
Manometer — 01

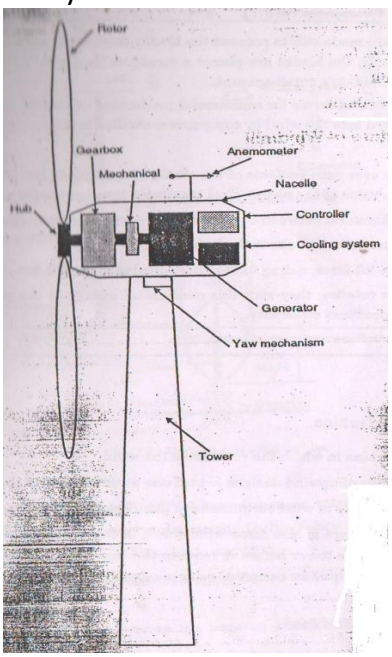


Gage Pressure $\Delta P = P - P_0 = \rho g h$

01

		These instruments are used to measure the pressure. A manometer measures the gauge pressure while the pi9tot tube measures the total pressure i.e. the sum of static and dynamic pressure. Pitot tube is useful to measure the air velocity in the ducts.	
Q4	**A**		
	a.	Effect of greenhouse gases on climate change : The effect of earths atmosphere due to trapping of long wavelength infrared radiations by the CO2 layer in the atmosphere is called green effect. CO2 produced by power plants has no ill effect on human life biologically but increased concentration of it may cause the climate change due to its heat trapping quality leading to green house effect.	02
		Global Warming: It is also called as climate change. It refers to the long term fluctuations in temperature, precipitation, wind and earth elements of the earth climate system.	02
	b	**Advantages & Disadvantages of Concentrating collectors over flat plat collectors** **(02 marks for advantages and 02 for disadvantages)** **Advantages :** 1) High fluid temperatures up to 500 o C 2) High collector efficiency 3) Reduced thermal losses 4) Low cost as less material required **Disadvantages :** 1) Collects only beam radiations 2) Needs costly tracking device 3) Needs extensive maintenance 4) High initial cost 5) Non uniform flux on absorber plane	
	c	**Working of Francis Turbine** In Francis Turbine water flow is radial into the turbine and exits the Turbine axially. Water pressure decreases as it passes through the turbine imparting reaction on the turbine blades making the turbine rotate. Francis Turbine has a circular plate fixed to the rotating shaft perpendicular to its surface and passing through its center. This circular plate has curved channels on it; the plate with channels is collectively called as runner. The runner is encircled by a ring of stationary channels called as guide vanes. Guide vanes are housed in a spiral casing called as volute. The exit of the Francis	02

		turbine is at the center of the runner plate. There is a draft tube attached to the central exit of the runner. Francis Turbines are generally installed with their axis vertical. Water with high head (pressure) enters the turbine through the spiral casing surrounding the guide vanes. The water looses a part of its pressure in the volute (spiral casing) to maintain its speed. Then water passes through guide vanes where it is directed to strike the blades on the runner at optimum angles. As the water flows through the runner its pressure and angular momentum reduces. This reduction imparts reaction on the runner and power is transferred to the turbine shaft.  	02
	d	Biomass energy Sources: 1. Wood waste 2. Sugar cane 3. Land crop 4. Aquatic crop	
Q.4	**B**		06
	a	A small hydro electric project consists of the following : **1.Reservoir** : used to store water during rainy season. This water is used to run the hydraulic turbine **2.Dam** : It is a structure of considerable height built across the river. It provides working head of water for power plant **3.Gate** : It is provided for controlling of flow of water from reservoir to turbine **4.Waterway and penstock**: Waterway carries water from the dm to the power house. It includes canal and penstock or tunnel **5.Hydraulic turbine**: These are used to convert the kinetic energy of water into mechanical energy	02

	b	Waste heat Recovery system Waste heat is energy that is rejected to the environment. It arises from equipment and operating inefficiencies, as well as from thermodynamic limitations on equipment and processes. Often, part of waste heat could potentially be used for some useful purpose. At present, about 20 to 50% of energy used in industry is rejected as waste heat . A significant part of this wasted energy is low-temperature heat that is sent to the atmosphere mainly from cooling water, fin-fan coolers and flue gases. Usually, distillation column overhead streams at temperatures of 100–200 0C reject heat by fin-fan coolers, and streams at a temperature less than 100 0C reject heat to the cooling water system. WHR can be defined as the process of capturing some portion of the heat that normally would be wasted, and delivering it to a device or process where it can be used as an effective, economical and environmentally friendly way to save energy. Large investments are presently incurred to exhaust waste heat to the atmosphere in the form of cooling towers, fin-fan coolers and very tall stacks for the disposal of flue gases. WHR has the potential to minimize these costs, and to reduce environmental impact along with several other benefits.	06
Q5	**a**	**Working of wind energy system with main components** 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  	04 02

b. In order to take full advantage of solar energy it must be stored in some form of solar energy storage system. Unfortunately, the time when solar energy is most available, it will rarely be consumed because the solar energy is available at day time while the demand is maximum at prime time. There is also the problem of clouds with photovoltaic plants, and cloud cover for several days may result in substantially lowered electrical output compared to bright sunny cloud-free days. During such days energy previously stored during bright sunny times could be used to provide a continuous electrical output or thermal output.

1. Solar energy storage through Sensible heat storage
2. Solar energy storage through Water storage system
3. Solar energy storage through Pebble bed
4. Solar energy storage through Latent heat storage (Phase change energy storage)
5. Solar energy storage through Electrical storage system
6. Solar energy storage through Chemical storage system
7. Thermo – chemical energy storage
8. Pumped hydroelectric storage of solar energy
9. Solar energy storage through compressed air
10. Solar energy storage I Flywheel

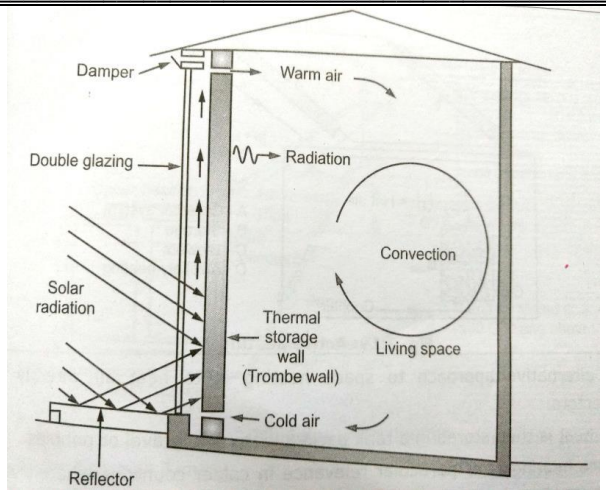
½ mark each

c **Passive solar space heating system** :

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

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

04



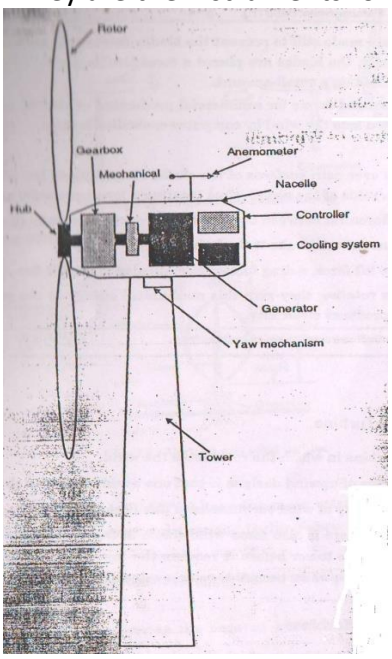
d Direct or beam radiation: Sunlight is the total spectrum of electromagnetic radiation given by the Sun. Solar radiation that has not been absorbed or scattered and reaches the ground directly from the Sun is called direct or beam radiation. 2M each

Diffuse Solar radiation: It is that solar radiation received from the sun on the earth after its direction has been changed.

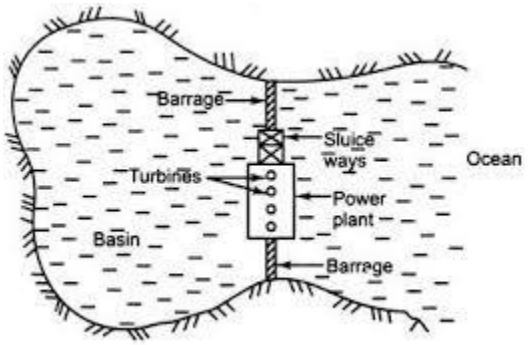
e

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

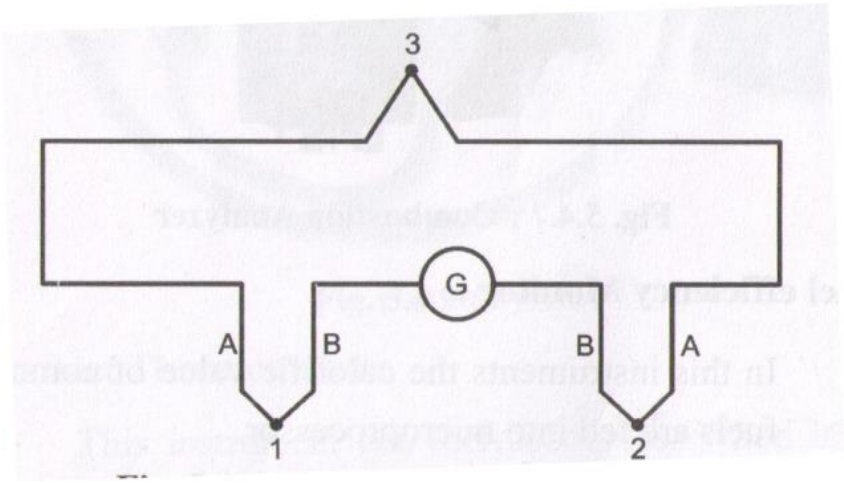
02



02

	f	**Basin arrangement of tidal power generation** Single basin system can generate power only intermittently. This is the simplest system of generating tidal power. The single basin scheme has only one basin. The basin is separated from the sea by a dam (barrage, Dyke). The sluice way is opened during high tide to fill the basin. The turbine-generator units are mounted within the ducts inside the barrage.  **Layout of single basin tidal plant**	02 02
Q6	**a**	Thermal energy storage is like a battery for a building's air-conditioning system. It uses standard cooling equipment, plus an energy storage tank to shift all or a portion of a building's cooling needs to off-peak, night time hours. During off-peak hours, ice is made and stored inside Ice Bank energy storage tanks. Heating of a solid or liquid which does not change phase is called sensible heat storage. Energy can be stored in the form of latent heat caused by phase change during heating either from solid to liquid or liquid to vapour.	02 02
	b	**Applications of solar energy:** 1. Solar water heating 2. Solar cookers 3. Solar distillation 4. Solar drying 5. Solar green houses 6. Solar power generation 7. Solar photovoltaic cell for electric power generation 8. Solar Furnaces 9. Heating and cooling of residual building Advantages	

	c	1. It is available free and is enexhaustible 2. It is clean and non polluting 3. Have low maintenance cost 4. Has low cost of power generation Disadvantages 1. Capital cost is high. 2. Available is dilute energy and fluctuating 3. Large variation wind speed 4. Design system is difficult	02 02
	d	**i) List of materials used for bio gas generation** Almost any organic material can be processed with anaerobic digestion. Anaerobic digestion is particularly suited to wet organic material and is commonly used for effluent and sewage treatment. This includes biodegradable waste materials such as waste paper, grass clippings, leftover food, sewage and animal **ii)Main application of biogas:** This energy release allows biogas to be used as a fuel; it can be used for any heating purpose, such as cooking. It can also be used in a gas engine to convert the energy in the gas into electricity and heat.Biogas can be compressed, the same way as natural gas is compressed to CNG, and used to power motor vehicles.	02 02
	e	**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 $6CO2 + 6H2O + \text{light energy} = C6H12O6+6O2$ Total energy stored in the photosynthesis process is about 4500 Kj Conditions for Photosynthesis:- 1 Chlorophyll must be present in leaf cells for photosynthesis to occur. 2 Leaves must be exposed to light for photosynthesis to occur. 3 Plants need carbon dioxide to be able to photosynthesise.	04 02

	f	**Angstrom Pyrheloimeter**:- This pyrheliometer has a rectangular aperture, two manganin-strip sensors (20.0 mm × 2.0 mm × 0.02 mm) and several diaphragms to let only direct sunlight reach the sensor. The sensor surface is painted optical black and has uniform absorption characteristics for shortwave radiation. A copper-constantan thermocouple is attached to the rear of each sensor strip, and the thermocouple is connected to a galvanometer. The sensor strips also work as electric resistors and generate heat when a current flows across them. When solar irradiance is measured with this type of pyrheliometer, the small shutter on the front face of the cylinder shields one sensor strip from sunlight, allowing it to reach only the other sensor. A temperature difference is therefore produced between the two sensor strips because one absorbs solar radiation and the other does not, and a thermo electromotive force proportional to this difference induces current flow through the galvanometer. Then, a current is supplied to the cooler sensor strip (the one shaded from solar radiation) until the pointer in the galvanometer indicates zero, at which point the temperature raised by solar radiation is compensated by Joule heat.  	03 01