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 should assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given 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 should give credit for any equivalent figure/figures drawn.

5) Credits to 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 (as long as the assumptions are not incorrect).

6) In case of some questions credit may be given by judgment 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

1 Attempt any FIVE of the following 20

1 a) Define primary energy sources, secondary energy sources and supplementary sources with its examples.

Ans:

1) **Primary energy sources:** The energy sources which provide net supply of energy are called primary energy sources. Its examples are coal, oil, gas, uranium etc. These are available in nature in raw form and need to processed and converted into a suitable form before use.
2) **Secondary energy sources:** The energy sources which are obtained from primary energy sources by processing. These sources produce no net energy. The processing transforms the primary sources into secondary or usable energy form so that it can be utilized by consumers. Its examples are electricity, steam, petrol, diesel, LNG, CNG etc.
3) **Supplementary energy sources:** The energy sources whose net energy yield is zero and those requiring highest investment in terms of energy. Insulation (thermal) is an example for this source.

3 marks for definitions + 1 mark for examples = 4 marks

1 b) Explain the prospects of renewable sources of energy with reference to Indian context.

Ans:

Hydro-electric potential indicates that the exploitable potential is about 400 TWh of annual energy generation. The energy potential of 40 TWh have already been constructed. The 360 TWh of annual energy generation is located in northern and north-eastern region.

The intensity of use of electrical energy in the Indian economy has shown a steady increase. This trend necessitated substantial increase in the share of investment.

According to the assessment by Ministry of Non-conventional Energy Sources (MNES), India has potential of 135,853 MW from renewable energy sources, while 14,914 MW has been installed. Renewable sources can provide both grid connected power and off-grid power for lighting, pumping, thermal and heat generation and transportation.

Renewable power status and potential:

Sr. No.	Sources	Potential (MW)	Installed (MW)
1	Wind Energy	48,561	10,464
2	Small hydropower	14,292	2,461
3	Biogas	5,000	1,555
4	Bio-power	61,000	773
5	Waste Energy	7,000	59
6	Solar photovoltaics (SPU)	20	2
Total		135,853	14,914

2 marks for quantitative data + 2 marks for explanation

New solar power generation technologies such as concentrating solar thermal power (CPS) and concentrating photovoltaics (CPV) are being developed. These new technologies are capable of large-scale power generation. Rajasthan has tremendous potential of solar power. There is higher potential for wind power in states like Tamilnadu, Gujrat and Maharashtra. India does not appear to have any major exploitable geothermal source. The potential for biomass from agricultural

residues alone is estimated as 480 mt with residues from food grains contributing around 100 mt.

1 c) Define the following terms related to solar radiation geometry
(i) Latitude of location
(ii) Declination
(iii) Solar azimuth angle
(iv) Zenith angle

Ans:

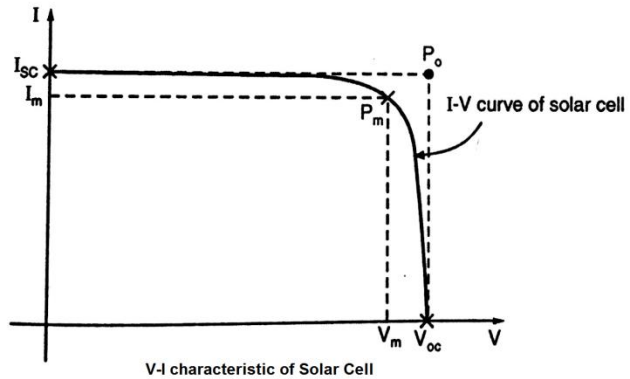
1) **Latitude of Location:** It is the angle made by the radial line joining the location to the centre of the earth with the projection of the line on the equatorial plane.
2) **Declination:** It is the angular distance of the Sun's rays north (or south) of the equator. It is the angle between a line 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.
3) **Solar Azimuth Angle:** It is the solar angle in degrees along the horizon east or west of north or it is a horizontal angle measured from north to the horizontal projection of the sun's rays.
4) **Zenith Angle:** It is the complimentary angle of Sun's altitude angle. It is the vertical angle between the sun rays and a line perpendicular to the horizontal plane through the point or the angle between the beam from the sun and the vertical.

1 mark for each definition = 4 marks

1 d) Draw the V-I characteristics of solar cell. Also define the efficiency of solar PV cell.

Ans:

Figure shows the V-I characteristic of a solar cell.



V-I characteristic of Solar Cell

Efficiency of Solar PV Cell:

The efficiency of the solar cell is defined as the ratio of the maximum possible solar cell output power (P_m) to the input solar radiation power (P_{rad}).

$$\eta = \frac{P_m}{P_{rad}}$$

Standard solar radiation power (P_{rad}) is 1000 W/m^2 at temperature of 25°C.

2 marks for Figure + 2 marks for definition = 4 marks

1 e) State the salient features and characteristics of induction generators used in wind mills.

Ans:

Salient Features of Induction Generators used in Wind Mills:

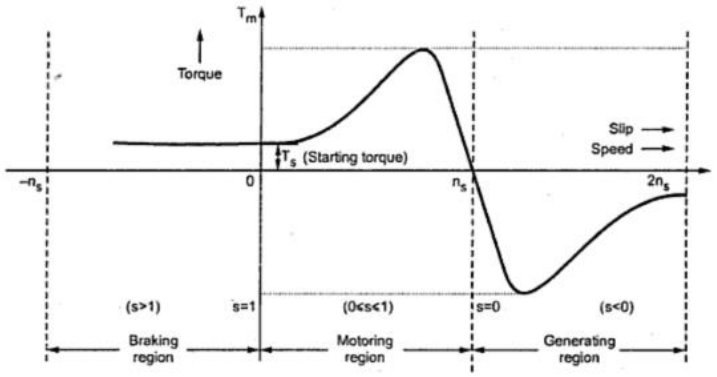
i) Simpler construction than synchronous generators
ii) Easy to operate and maintain
iii) Simple controls as compared to synchronous generators
iv) No synchronization problems.

½ mark for each of any four features

v) Less costly i.e economical

Characteristics of Induction Generators:

The torque-speed or slip characteristic of induction generator is shown in the figure.



When the load drives the rotor at speed higher than the synchronous speed i.e slip is negative, the induction machine receives the mechanical energy and converts it into electrical energy operating as induction generator.

1 mark for diagram + 1 mark for explanation

1 f) What are the different biomass energy resources? Briefly explain about 'combustion' method of obtaining energy from biomass.

Ans:

Different Biomass Energy Resources:

i) Forests: Natural or cultivated forests are source of wood, charcoal, producer gas, forest waste, certain seeds which can be used to produce biofuel.
ii) Agricultural Residues: Straw, rice husk, groundnut shell, coconut shell, sugarcane bagasse
iii) Energy Crops: Sugar plants, Starch plants, oil producing plants
iv) Urban waste: Garbage, Municipal solid waste, sewage or liquid waste.
v) Aquatic Plants: Water hyacinth, seaweed, algae, kelp.

½ mark for each of any four resources + 2 marks for combustion = 4 marks

Combustion method of obtaining energy from biomass:

When biomass based fuel is burnt in the presence of air, it produces heat energy. The process by which energy is produced by the burning of biomass is known as Combustion. Direct combustion of animal waste such as dung cakes, wood waste such as tree leaves and branches, bagasse, charcoal produce large amount of heat. This method is traditionally used worldwide in so called Chulhas. The amount of heat energy produced depends upon the calorific value of the biomass material.

1 g) State the applications and advantages of Hydrogen energy.

Ans:

Applications of Hydrogen Energy:

i) To generate electricity using fuel cell.
ii) It can be used as fuel in domestic cooking in place of LPG.
iii) Energy source for running vehicles.
iv) To fuel IC engine similar to gasoline or natural gas to obtain mechanical or electrical energy.
v) In gas turbines to obtain mechanical energy.
vi) In boilers for steam generation to run steam turbines.

½ mark for each of any four applications (2 marks)

Advantages of Hydrogen Energy:

i) Less cost as compared to conventional fuels
ii) It is produced from water which is available and renewable.

½ mark for each of any four

iii) It has highest energy content per unit of mass.
iv) Burning process is non-polluting.
v) It can be transmitted and distributed by pipeline.
vi) It can be economically and technically stored as and when required.

advantages (2 marks)

2 Attempt any TWO of the following: 16 marks

2 a) Explain the energy scenario in India in context of energy production, energy consumption, various sources and their limitations.

Ans:

Energy Production:

India is the seventh largest economy in the world. With increased population, energy demand has increased to greater extent. So there is huge demand of energy resources. India has potential for both renewable and non-renewable energy resources. India has installed capacity of 2,11,766 MW power from all resources as on 31/01/2013. India has an estimated potential of over 2,45,000 MW from various renewable energy sources and installed capacity of 25,856 MW from renewable sources. India is now promoting the use of renewable energy sources for clean and eco-friendly electricity production. 2 marks

Energy Consumption:

Energy is an important input in all the sectors of any country's economy. The standard of living of any country can be directly related to per capita energy consumption. Per capita consumption is defined as the gross electrical energy availability divided by the population of that country or region. The annual per capita consumption of electricity in India is 779 kWh (2009-10), which is much lower than the world's per capita energy consumption 2782 kWh. India is facing energy crisis due to increased energy consumption, which is because of increased population. 2 marks

Various Energy Sources:

In India, major electricity generation (66.91%) is done by thermal power stations using coal, oil and gas as fuel. The hydro-electric generation contributes about 18.61%. The Nuclear power generation capacity is low, 2.25%. However, the renewable energy sources are promising the future with 12.20% of power production. In today's scenario, India mostly depends on coal for its electricity generation. It contributes about 57% of the total installed capacity of the country. India has quite good potential for renewable resources, major are the solar and wind. India has potential of 135,853 MW for renewable energy resources, but only 14, 914 MW has been installed. 2 marks

Limitations:

i) Limited deposits of coal.
ii) Low calorific value of coal.
iii) Shipping cost is expensive.
iv) Coal pollutes the atmosphere while burning.
v) Oil reserves in India are very limited.
vi) Large scale electricity production is not possible with agricultural and organic waste.
vii) Installation cost of renewable technology based plants is very high.

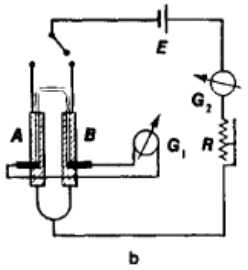
1 mark for each of any two limitations (2 marks)

2 b) Explain with suitable diagram the construction, working and limitations of pyrheliometer for measurement of beam radiation.

Ans:

Pyrheliometer:

i) **Construction:** In this instrument, two identical blackened manganin strips A and B are arranged in such a way that either can be exposed to radiation at the base of collimator tube by moving a reversible shutter.



b

2 marks for diagram

ii) **Working:** One strip is placed in radiation and a current is passed through the shaded strip to heat it to the same temperature as the exposed strip. When there is no difference in temperature, the electrical energy supplied to shaded strip must be equal the solar radiation absorbed by the exposed strip. Solar radiation is then determined by equating the electrical energy to the product of incident solar radiation, strip area and absorptance.

2 marks for construction

2 marks for working

iii) **Limitations:** The problems with the pyrheliometers are the aperture angle, the circum solar contributions and imprecision in the tracking mechanism. The first two are almost impossible to eliminate because of the inability to define the solar disk precisely and the finite dimensions of the instrument components. The use of correction factors is not only involved but somewhat unreliable.

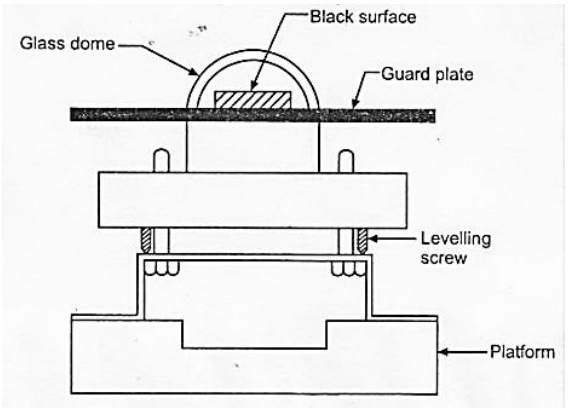
2 marks for limitations

2 c) Describe the construction and limitations of pyranometer used for measuring total solar radiations.

Ans:

Pyranometer:

i) **Construction:** A pyranometer is an instrument which measures total or global radiation over a hemispherical field of view. It consists of a "black surface" which receives the beam as well as diffuse radiations which produces heat. A "glass dome" prevents the loss of radiation received by the black surface. A "thermopile" is a temperature sensor and consists of a number of thermocouples connected in series to increase the sensitivity. The "supporting stand" keeps the black surface in a proper position. The sun's radiation is allowed to fall on a black surface to which the hot junctions of a thermopile are attached. The cold junctions of the thermopile are located in such a way that they do not receive the radiation. As a result, an emf proportional to the solar radiation is generated.



4 mark for construction + 2 marks for diagram + 2 marks for limitations = 8 marks

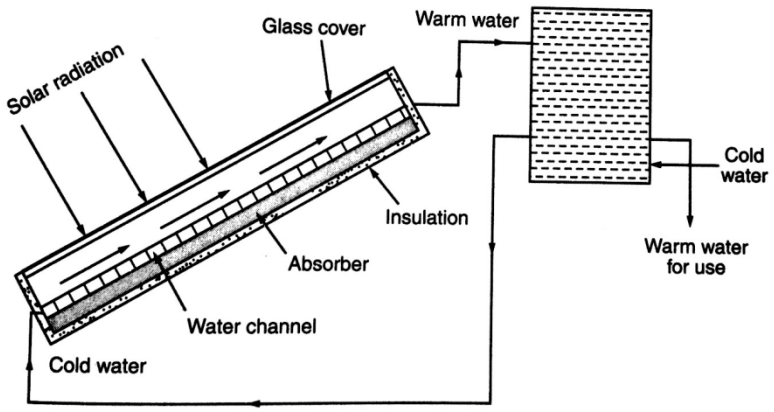
ii) **Limitation:** If shading ring is attached, the beam radiation is prevented from falling on the instrument sensor and then measures only diffuse component of the radiation.

3 Attempt any TWO of the following 16

3 a) Explain with neat sketch the construction, working and application of flat plate collector.

Ans:

Flat plate Collector:



Solar water heater using a flat plate collector

2 marks

Construction: It consists of solar radiation collector or absorber, glass cover, insulating material and water pipe The most important part is its solar radiation absorber which derives heat energy from sunrays. The absorbing material is typically a flat metal sheet. Water carrying pipe is attached to this sheet. The obsorber plate is insulated at the back and at the side to insulate it from ambience for minimizing the heat losses. At the front side, transparent glass is kept which allows solar radiation to fall on the absorber metal sheet & prevents upward thermal losses. Eventually the insulated absorber plate and pipe / channel assembly is connected to the water tank through pipes as shown in figure.

3 marks

Working: The absorber plate receives the solar radiation and gets heated . The heat is then transferred to the water channel and water therein. Hot water has low density as compaired to the cold water. Due to this density difference, cold water at inlet pushes the hot water in the water channel, sending it up all the way to out let and to the water tank. This water circulation pattern gets set automatically due to density difference.

2 marks

Application: The flat plate solar water system is used for domestic and industrial applications for heating water up to a temperature of about 60^0C to 70^0C. A well designed system can provide the heat at low cost for long duration.

1 marks

3 b) With the functional block diagram of photovoltaic power generating system, explain its operation. Also state its advantages & disadvantages (any two)

Ans:

Photovoltaic Power Generating System:

Operation: Solar PV panel converts solar energy to electrical energy in dc form. The electrical energy is generated when sunlight falls on the PV panel. There is no sunlight during cloudy days and night hours, so battery is used here Electricity supplied to the appliance and also for battery charging when sunlight is there. Some of appliances are of dc type and can utilize dc output of PV panel directly but many

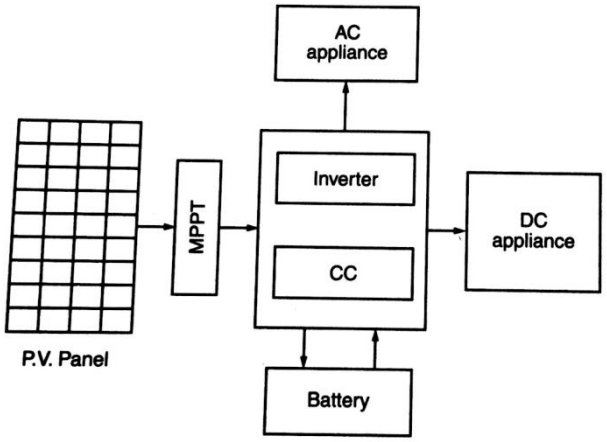
2 marks for operation

of the appliances are of ac type, hence dc supply of PV panel is converted into ac with the help of inverter. Overcharging and overdischarging of battery shortens its life so this needs battery protection by a device called charge controller (cc). Which prevents Overcharging And over Overdischarging of battery. Maximum power point tracker (MPPT) is an impedance matching device which is used alongwith PV panel to extract maximum power. 2marks for block diagram

Advantages :

1. System is durable.
2. No Operation cost
3. Low maintenance.
4. More flexibility available.
5. Systems are eco friendly.
6. Highly reliable.
7. Long effective life.
8. Absence of moving facts.
9. Can function unattended for long period.
10. High power to weight ratio.
11. Natural sunlight is used as Input energy.
12. Pollution free system.

1 mark for each of any two advantages (2 marks)



Block diagram of photovoltaic system

Disadvantages :

1. Weather dependant.
2. Low efficiency.
3. High Installation cost.
4. Storage is required.

1 mark for each of any two disadvantages (2 marks)

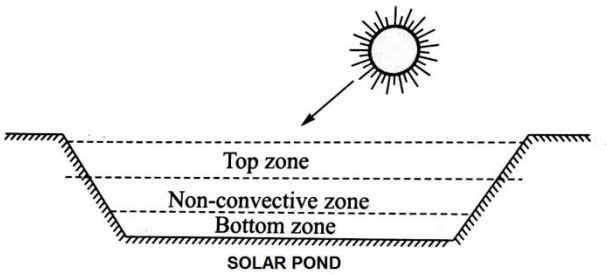
3 c) Explain with the principle, working and advantages of solar pond.

Ans:

Solar Pond:

Principle: In general pond, when water is heated up by the sun rays the heated water rises to the top of the pond. The hot water loses heat to the atmostphere & so the net tempature at the top of the pond remains nearly at atmospheric temperature. The solar pond technology ensures that heated brine water remains at the bottom of the pond due to more brine concentration and density in it.

2 marks for diagram



2 marks for principle

Working: The solar pond consists of a large size brine pond (depth almost about 1 meter) which has salt concentration gradient in such a way that most concentrated and dense part of the brine solution is at the bottom of the pond & brine concentration gradually reduces from bottom to top of the pond based on the

2 marks for working

variation of brine solution density. A Solar pond has three zones as shown in fugure. The top zone is surface zone which has the least salt content and its temperature is the atmospheric temperature. The bottom zone has the maximum salt content & it has a high temperature (70^0C to 85^0C). This is the zone that collects and stores the solar energy as heat energy. In between these two zones, there is the gradient non convective zone. Because of solar rays the the brine solution from the bottom becomes hot which is taken out from the pond & used to evaporate an organic working fluid in a heat exchanger & then supplied back to the pond. The heated organic working fluid produces mechanical power in a rankine cycle which then drives the turbine & ultimetely the generator.

Advantages:

1) Simple in construction
2) Natural sunrays are used as input energy which is locally available.
3) Systems are eco –friendly
4) Serves dual purpose. i.e heat cullection as well as storage.
5) Pollution free system
6) Operation is easy.
7) No special attention is required.

½ marks for each of any four advantages (2 marks)

4 Attempt any FOUR of the following: 16

4 a) Define tilt factor for beam radiation. State the factor on which the value of tilt factor depends.

Ans:

Tilt factor for beam radiation: The ratio of the beam radiation flux falling on a tilted surface to that falling on a horizontal surface is called as the Tilt factor for beam radiation. 1 mark for definition

Tilt factor for beam radiation depends on: 1 mark for each factor (max. 3 marks)

1) Horizontal tilt
2) Surface Azimuth
3) Declination angle
4) Latitude

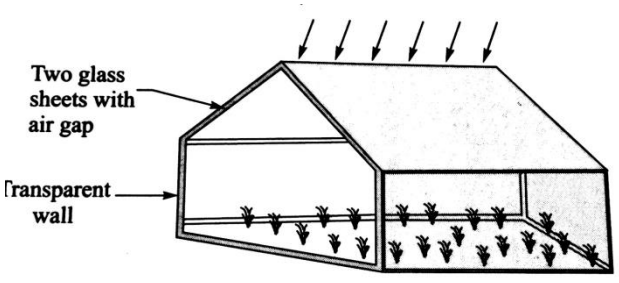
4 b) Explain the construction and application of solar green house.

Ans:

Solar Green House:

Construction:

A green house is a shed or enclosure in which a proper environment is provided to enable the growth and production of vegetables and flowering plants even during adverse and severe climatic conditions prevailing outside.



Greenhouse for cold climate.

1 mark for diagram

2 marks for construction

A typical green house is shown in figure. To ensure enough sunlight inside the green house, sufficient glass or transparent plastic sheet is provided in roof and

walls in the greenhouse facing the sun. For roof, two layers of glass or plastic sheets are provided with small air gap in between to obtain proper thermal insulation. The air gap helps in entrapping the solar radiation inside the green house. Adequate presence of carbon dioxide is ensured by (i) supplying outside air (ii) Using organic manure (iii) combustion of sulphur free fossil fuels and (iv) carbon dioxide gas.

Application:

In green house, visible light, carbon dioxide and water are provided as required for photosynthesis process, which can be given as

Light energy + CO_2 + water = Carbohydrate + O_2

The carbohydrate produced in photosynthesis is used by plants during respiration process for growth, which can be given as

Carbohydrate + O_2 = CO_2 + energy + water

Any vegetable or flowering plants can be grown throughout the year if suitable environment conditions are provided by green house.

1 mark for application

4 c) State any four advantages of solar water pumping system.

Ans:

Advantages of solar water pumping system:

1) More irrigation water is required in summer when solar energy is available most.
2) Pumping can be carried out intermittently without any problem
3) Surplus pumped water can be stored in a reservoir / pond / tank
4) The requirement of water decreases during period of low radiations.
5) It is relatively inexpensive.
6) Running and maintenance cost is low.

1 mark for each of any four advantages = 4 marks

4 d) State the areas of application of wind energy. Explain any one in brief.

Ans:

Wind turbines have been built in power output range from 1kW to few MW to suit a wide range of applications. The major application areas may be

(1) Wind pumps
(2) Space heating
(3) Water heating
(4) Operating domestic appliances
(5) Navigation signal / Remote communication
(6) Supply power to isolated populations
(7) As grid connected electrical power source

½ marks for each of any four areas of applications (2 marks)

(i)Wind Pumps: Low power turbines are used for producing mechanical power for pumping water in remote areas. The wind pumps are used to supply water for livestock, small scale irrigation, domestic supply etc.

(ii)Space heating: The mechanical power produced by wind turbine can generate sufficient electrical energy for space heating.

(iii)Water heating: Low power wind generator can generate electricity for water heating applications in residential / commercial / industrial purposes.

(iv)Operating domestic appliances : Machines of low power can generate sufficient electrical energy for battery charging and for operating domestic appliances such as

2 marks for explanation of any one

fan , lights, & small tools.
(v) Navigation signal / remote communication: Application of somewhat more powerful turbines of about 50 kW are producing electricity for navigation signal, remote communication weather stations and offshore oil drilling platforms.
(vi)Supply power to isolated populations: Intermediate power range (100 kW to 250 kW) aero generators can supply power to isolated populations, farms, co-operatives, commercial, refrigeration, desalination and to other small industries.
(v)As grid connected electrical power source: Large aero generators in the range few hundred kW to few MW are planned for supplying power to a utility grid.

4 e) Explain briefly the anaerobic digestion method of obtaining energy from biomass

Ans:

Anaerobic digestion:

The process which converts decaying wet biomass and animal waste into biogas through the decomposition process by the action of anaerobic bacteria (bacteria that live & grow in absence of oxygen) is called anaerobic digestion. — 1 mark for definition

$$Decying\ wet\ biomass \xrightarrow{Anaerobic\ fermentation\ (20-55^{\circ}C)} Biogas\ (Largly\ CH_4 \& CO_2)$$

The air tight equipment used to convert the wet biomass into biogas by digestion or fermentation is called digester. The biochemical process of conversion from biomass to biogas is as in three stages: — 1mark for each stage (max. 3 m)

(i) Hydrolysis of organic matter: The biomass is broken due to the action of water (hydrolysis) into simpler soluble compounds.
(ii) Anaerobic & facultative microorganism: These bacteria start growing to produce acetic & propionic acids. The output of process is the production of carbon dioxide.
(iii) Digestion: Anaerobic bacteria slowly digest the biomass slurry to produce biogas the process is completed in two weeks.

4 f) State any four main components of Tidal power plants and their functions.

Ans:

Tidal Power Plants:

The main components of Tidal power plants are:

1) Dam or Barrage or Dyke: The function of dam or dyke or barrage is to form a barrier between the sea and the reservoir / basin. Dam is used for storage of water for obtaining a good water head.
2) Sluice ways: Sluice ways are provided in the dam so that water can enter into basin during high tides. These may also be provided to empty the basin during high tides.
3) The power house: This consist of turbines, electrical generator and other auxiliary equipment.
4) Turbine: Because of small heads available in the tidal power plants, large size of turbines is needed. For low heads i) Bulb turbine, ii) Tube Turbine, iii) Straight flow Rim type turbines are used. These converts tidal energy into mechanical energy.
5) Generators: The water with high potential energy is made to run through turbines which are coupled to Alternator for generation of electrical power.

1 mark for each of any four components = 4 marks

5 Attempt any TWO of the following: 16

5 a) Explain the main considerations of site selection for Wind Energy Conversion System.

Ans:

Site selection for Wind Energy Conversion System (WECS):

Following points are considered for selection of site for installation of WECS:

i) High annual average wind speed:
The fundamental requirement to the successful use of WECS is obviously an adequate supply of wind. The wind velocity is critical parameter. The power in the wind is directly proportional to third power of wind velocity. Therefore, a site with high wind velocity is desirable.

ii) Availability of anemometry data:
The information about the wind speed, its variation over some time span and also with height from ground is very important for selection of capacity of WECS.

iii) Availability of wind $V_{(t)}$ curve at the proposed site:
This curve determines the maximum energy in the wind and hence is the main controlling factor in predicting the electrical output and hence the revenue returns of the WECS.

iv) Wind structure at the proposed site:
A site with flat $V_{(t)}$ curve indicating smooth steady wind all the time is desired. The departure of wind from homogeneous flow with change in direction and in velocity, is referred to as "Wind structure".

v) Altitude of the proposed site:
It affects the air density and thus the power in the wind and ultimately the electrical power output. The wind tends to have higher velocities at higher altitudes.

vi) Terrain and its aerodynamics:
This is important to know the pass region of wind so that higher power can be harnessed.

vii) Local ecology:
It affects the wind structure, so the hub height is decided by this.

viii) Distance to roads and railways:
This is important for transportation of heavy machinery, materials, structures etc.

ix) Nearness of site to local centre / users:
It minimizes the length of transmission lines, resulting lower losses and costs.

x) Nature of ground:
To secure the foundations of WECS, the nature of ground is important.

xi) Favourable land cost:
Land cost should be favourable as it directly affects the total WECS system cost.

xii) Other conditions such as icing problem, salt spray or blowing dust which affect the aeroturbine blades and machinery.

1 mark for each of any 8 points = 8 marks

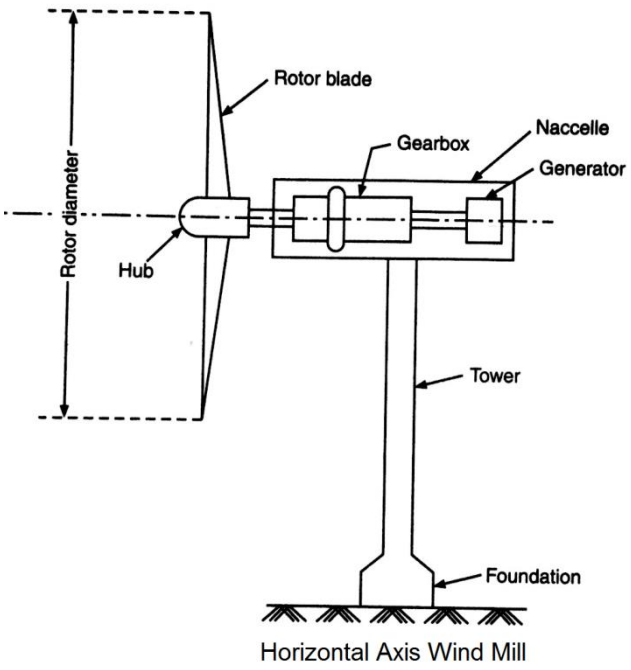
5 b) Explain construction, working, advantages and disadvantages of horizontal axis wind mill.

Ans:

Horizontal axis Wind Mill:

Construction:

In this type of wind mill, the rotor drives a generator through a step up gear box. The blade rotor is usually designed to be oriented downwind of the tower. The components are mounted on a bed plate which is attached on a pintle at the top of the tower. This type of wind mill has five-systems:



Horizontal Axis Wind Mill

1 mark for diagram

i) Rotor: It consists of two or three blades mounted on a hub and also has pitch control system.

ii) Shaft-system: It includes gearbox, hydraulic system, shafts and breaking system.

2 marks for construction

iii) Yaw system: This system helps in positioning the rotor blades perpendicular to wind stream.

iv) Electrical and electronic system: It consists of generator, protective relays, circuit-breakers, control and electronic devices and sensors, cables etc.

v) Tower: It supports the nacelle.

Working:

A wind mill is a machine for wind energy conversion. The wind turbine converts the kinetic energy of the wind's motion to mechanical energy transmitted by the shaft. The generator further converts it to electrical energy, thereby generating electricity. The horizontal axis rotors can be either lift or drag devices, but usually lift devices are preferred. For given swept area, high rotational speeds and more output can be developed by the lift forces that drag forces.

1 mark for working

Advantages:

i) The horizontal axis wind turbine technology is fully developed.
ii) These wind mills are more efficient.
iii) These wind mills provide smooth output.
iv) They are less noisy.
v) They extract more power from the wind.
vi) Pitch of blades can be controlled.
vii) They are designed to use lift force.
viii) Less fatigue to parts due to wind action.

½ marks for each of any four (max. 2m)

Disadvantages:

i) These wind mills are costly.
ii) Inspection and maintenance is difficult.
iii) Produce lower starting torque.

1 mark for each of any two (max. 2 m)

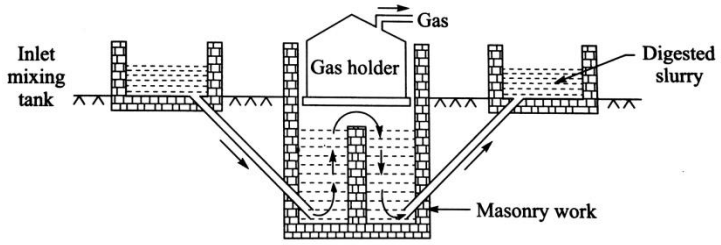
iv) Heavy and strong supporting structure is required.
v) Operation in low wind speeds is not satisfactory.

5 c) Explain in brief with neat sketch floating drum (constant pressure) type biogas plants and fixed dome (constant volume) type biogas plant. State their relative merits and demerits.

Ans:

Floating drum type biogas plant:

It consists of an underground cylindrical masonry digester having an inlet pipe for feeding animal dung slurry and an outlet pipe for digested slurry. There is a steel dome for gas collection, which floats on slurry. It moves up and down depending upon accumulation and discharge of gas guided by the dome guide itself. A partition wall is provided at the centre so that optimum conditions for growth of acid forming bacteria and methane forming bacteria can be provided. 1 mark

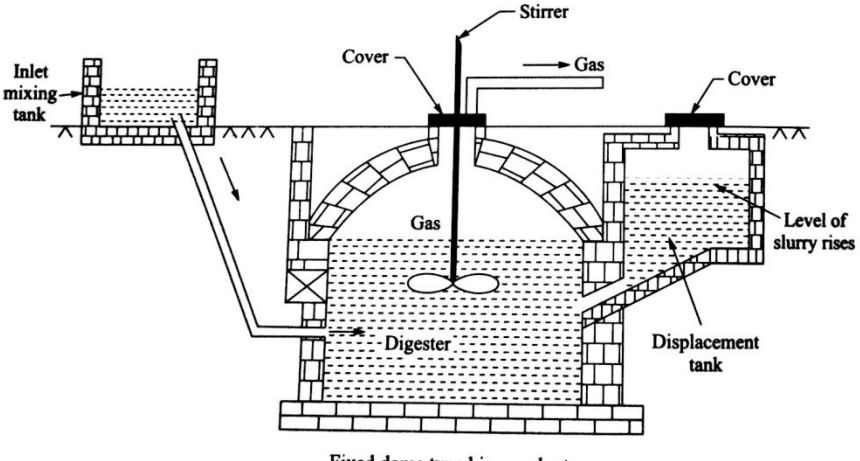


2 marks

Floating drum type biogas plant.

Fixed dome type biogas plant:

It consists of an enclosed digester combined with a dome shaped gas holder. This economical design is made of bricks, cement and masonry. It has no moving parts, so working life of the plant is more. Dung and water is mixed in inlet tank and the slurry so formed is fed into the digester through the inlet pipe. A stirrer is provided in the digester tank to mix the slurry inside the digester, which also helps in mixing of scum floating on the slurry. The produced gas accumulates in the fixed dome of the digester and it is taken out by an outlet pipe. The residual digested slurry is taken out from an opening in the digester. As the pressure of gas in the fixed increases, the level of the slurry inside the digester goes down and it forces the slurry to rise in the displacement tank. 1 mark



2 marks

Fixed dome type biogas plant.

Relative Merits and Demerits of Floating and Fixed Dome Type Biogas Plants:

Floating Drum type Biogas plant	Fixed Drum type Biogas plant
Constant pressure in digester	Constant volume in digester
No danger of explosion of gas as pressure in the digester is low	Danger of explosion exists as pressure is high
No danger of leakage gas	Due to high pressure, there is danger of leakage of gas
Cost is more due to floating steel drum provision	Less costly
Corrosion of steel floating drum is likely	No such danger
More maintenance needed due to sliding metallic drum	Less maintenance needed
High gas production due to lower pressure in digester	Low gas production due to high pressure in digester
Installation is simple	Installation is difficult

½ mark for each of any four points (max. 2 marks)

6 Attempt any TWO of the following: 16

6 a) Explain with neat sketch working of any one type of fixed bed gasifier.

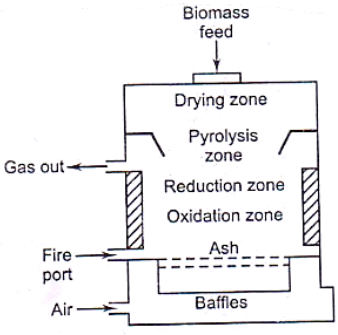
Ans:

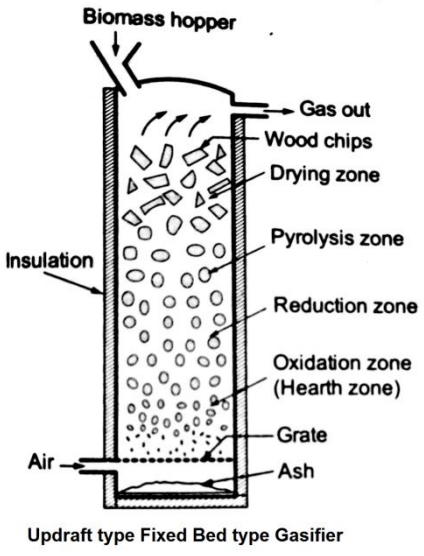
The fixed bed gasifiers are classified into three types:

i) Up-draft gasifier
ii) Down-draft gasifier
iii) Cross-draft gasifier

Updraft type Fixed Bed Gasifier:

Gasifier is the equipment that converts biomass into producer gas. The most common biomass materials are used are wood chips, agricultural wastes like coconut shells, straws, rice husk etc. The biomass material pass through high temperature zones and produce producer gas which consists of mainly carbon monoxide, hydrogen and oxygen. In this gasifier, the solid biomass is converted by a series of thermochemical processes like drying, pyrolysis, oxidation and reduction to a gaseous fuel – producer gas.





Updraft type Fixed Bed type Gasifier

3 marks for any one figure

2 marks for concept

3 marks for explanation

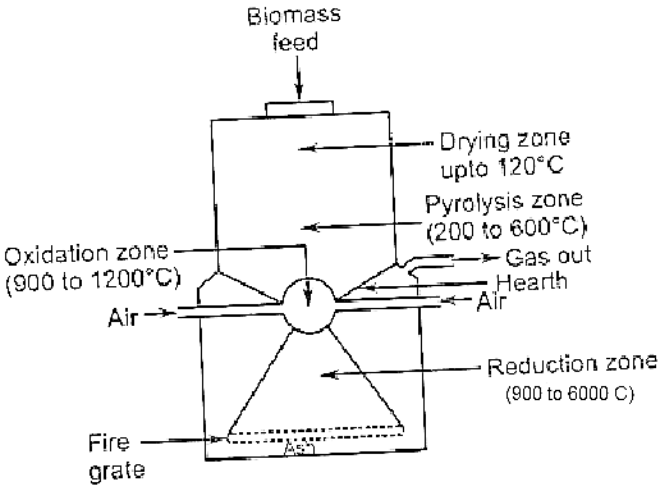
In this gasifier, air enters below the combustion zone and the producer gas leaves near the top of the gasifier, hence called updraft type gasifier. This type of gasifier is easy to build and operate. The updraft gasifier achieves highest efficiency as the hot gas passes through the fuel bed and leaves the gasifier at a low temperature. The gas produced has practically no ash but contains tar and water vapour because of

passing of gas through unburnt fuel. Hence the updraft gasifier is suitable for tar-free feed stock i.e fuels like charcoal.

OR

Downdraft type Fixed Bed Gasifier:

In downdraft gasifier, air enters at the combustion zone and gas produced leaves near the bottom of the gasifier. Fuel is loaded in the reactor from the top. As the fuel moves down, it is subjected to drying and pyrolysis where sloid char, acetic acid, methanol and water vapour are produced. Descending volatiles and char reach the oxidation zone, where air is injected to complete the combustion. The products moving downwards enter the reduction zone, where producer gas is formed by the action of CO_2 and water vapour on red hot charcoal. The producer gas contains products like CO_2, H_2 and CH_4. It is purified by passing it through coolers; tar is removed by condensation, whereas soot and ash are removed by centrifugal separation.



Downdraft type fixed bed type gasifier

3 marks for figure

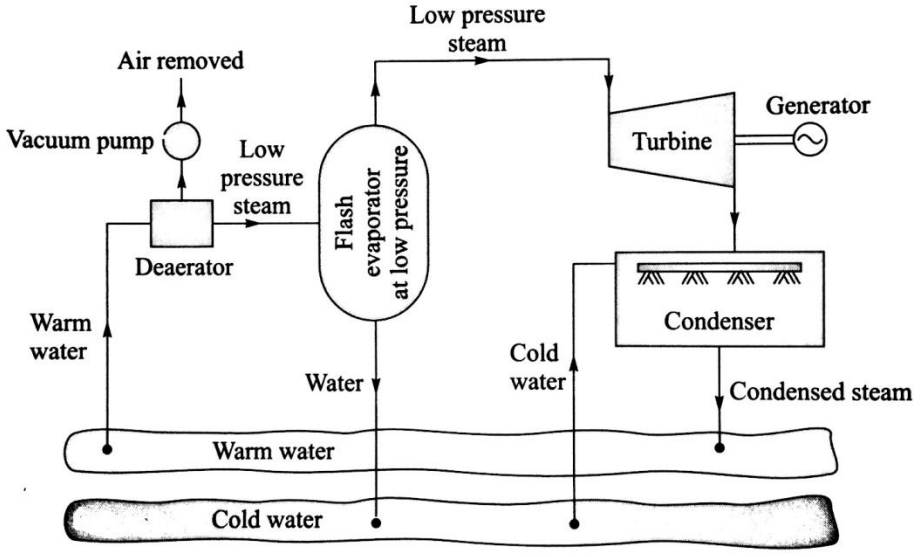
2 marks for concept

3 marks for explanation

6 b) Explain with neat sketch construction and operation of open cycle and closed cycle Ocean Thermal Energy Conversion (OTEC) plant.

Ans:

Open Cycle OTEC Plant:



Open cycle OTEC plant.

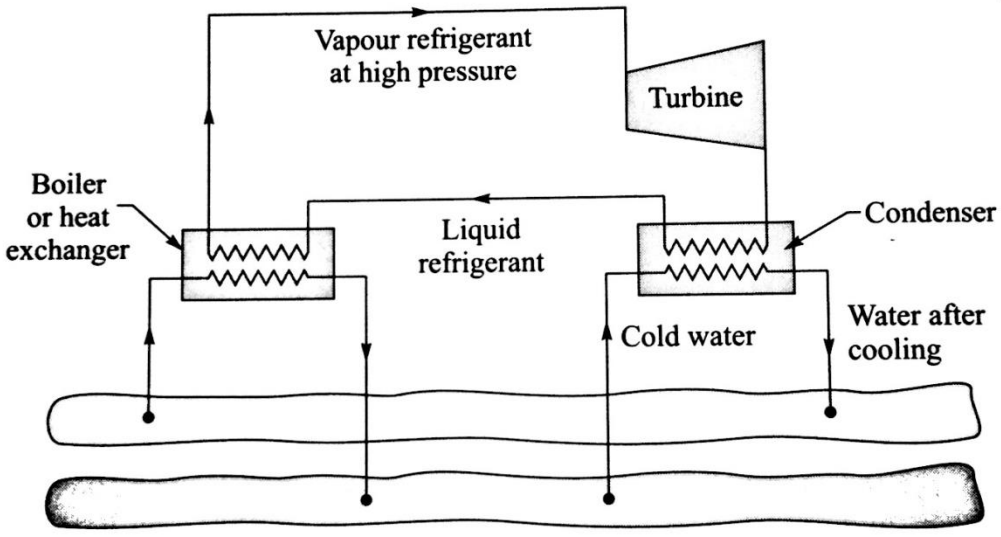
2 marks

Construction & Operation:

In this system, the warm water is converted into steam in an evaporator. The steam drives steam turbine coupled to generator, thus generating electricity. Figure shows schematic layout of open OTEC plant.

The warm water from ocean surface is admitted through a deaerator to the flash evaporator, which is maintained under high vacuum. As a result, low pressure steam is generated due to throttling effect and the remainder warm water is discharged back to the ocean at high depth. The deaerator also removes the dissolved non-condensable gases from water before supplied to the evaporator. The low pressure steam having very high specific volume is supplied to turbine where it expands and the mechanical power so developed is converted into electric power by the generator. The exhaust steam from the turbine is discharged into a direct contact type condenser, where it is mixed with cold water from ocean. The mixture of the condensed steam and ocean cold water are discharged into the ocean. Since the condensate is not directly fed to the evaporator for reuse, this cycle is called "open" cycle. 2 marks

Closed Cycle OTEC Plant:



Closed cycle OTEC plant. 2 marks

Construction & Operation:

A schematic layout of closed cycle OTEC plant is shown in the figure. The heat exchangers such as evaporator and condenser are key ingredients. This cycle requires a separate working fluid of low boiling point, such as ammonia, propane, Freon etc. These systems are located offshore on large floating platforms or inside floating halls.

The warm water from the ocean surface is circulated through a pump to a heat exchanger which acts as a boiler to generate working fluid ammonia vapour at high pressure. This vapour then expands in the turbine to develop mechanical power, which in turn runs the electric generator to produce electrical power. The working fluid vapour from turbine at low pressure is condensed in the condenser with the help of cold water drawn from the depth of ocean through a pump. The condensate 2 marks

is then supplied to evaporator for reuse. Since the working fluid is reused, this cycle is called "Closed" cycle.

6 c) State any four advantages, four disadvantages and four applications of geothermal energy. State the various geothermal sources.

Ans:

Advantages of Geothermal Energy:

i) Geothermal energy is cheaper, compared to the energies obtained from other sources both zero fuels and fossil fuels.
ii) It is versatile in its use.
iii) It is the least polluting compared to the other conventional energy sources.
iv) It is amenable for multiple uses from a single resource.
v) Geothermal power plants have the highest annual load factors of 85% to 90% compared to 45% to 50% for fossil fuel plants.
vi) It delivers greater amount of net energy from its system as compared to other alternative.

½ marks for each of any four (max 2 marks)

Disadvantages of Geothermal Energy:

i) Low overall power production efficiency about 15%, as compared to 35-40% for fossil fuel plants.
ii) The withdrawal of large amounts of steam or water from a hydrothermal reservoir may result in surface subsidence.
iii) The gases coming out of earth along with steam or hot water are hazardous, hence need to be removed by chemical action, before they are discharged.
iv) Drilling operation is noisy.
v) Large areas are needed for exploitation of geothermal energy.

½ marks for each of any four (max 2 marks)

Applications of Geothermal Energy:

i) Generation of electric power.
ii) Space heating for buildings
iii) Industrial process heat.
iv) Crop drying (Seawood, grass etc.)
v) Plastic manufacture
vi) Paper manufacture
vii) Heavy water production
viii) Timber seasoning
ix) Salt production from sea water
x) Sewage heat treatment

½ marks for each of any four (max 2 marks)

Various Geothermal Sources:

i) Hydrothermal or hydro-geothermal energy sources
ii) Geopressure resources
iii) Petro-thermal or hot dry rocks resources
iv) Magma resources
v) Valcanoes

1 mark for each of any two (max 2 marks)