

Q.1 Attempt any FIVE of the following :

[20]

Q.1(a) Classify solar and non-solar energy sources. Give its examples.

[4]

(A) (i) Non Conventional energy sources :

- (1) Solar energy
- (2) Wind energy
- (3) Tidal energy
- (4) Geothermal energy
- (5) Bio mass

(ii) Conventional energy sources :

- (1) Thermal energy
- (2) Nuclear energy
- (3) Coal
- (4) L.P.G
- (5) Crude oil

Q.1(b) State the uses of following instruments :

[4]

(i) Lux meter (ii) Pitot tube (iii) Pyrhelio meter (iv) Fyrite

(A) (i) Lux meter : To measure illumination level

(ii) Pitot tube : To measure the pressure

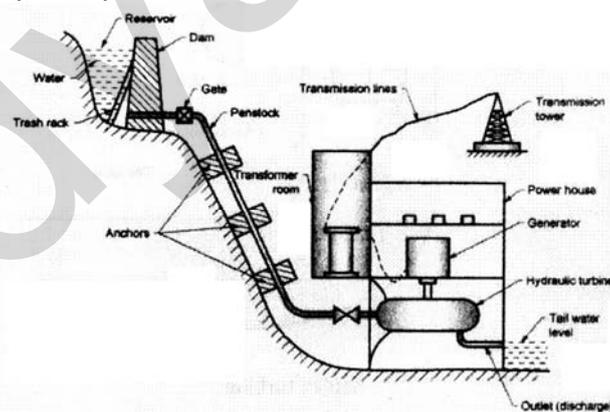
(iii) Pyrhelio meter : To measure beam radiations only

(iv) Fyrite : To measure the volume of O_2 , CO_2 and other gases

Q.1(c) With the help of a neat diagram explain the layout of a typical small Hydro-Electric plant.

[4]

(A) Small Hydro electric power plant :



A small hydro electric power plant consists of the following :

- (i) Reservoir : use to store water during rainy season. This water is used to run the hydraulic turbine.
- (ii) Dam : It is a structure of considerable height built across the river. It provides working head of water for power plant.
- (iii) Gate : It is provided for controlling of flow of water from reservoir to turbine.
- (iv) Waterway and penstock : Waterway carries water from the dm to the power house. It includes canal and penstock or tunnel.
- (v) Hydraulic turbine : These are used to convert the kinetic energy of water into mechanical energy.

Q.1(d) State the objectives and need of Energy Audit. [4]

(A) 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.

Objectives of energy Audit

The objectives of energy management are as follows:

- (i) To reduce energy consumption
- (ii) To minimize energy cost. It involves the following:
 - (1) Look for alternative sources of energy which is cheaper than existing source of energy.
 - (2) Reduce waste of energy.
 - (3) Adopt new technology requiring low energy consumption.
- (iii) Reduce emissions so as minimize environmental effects.

Need of Energy Audit : Energy audit takes a thorough look at a particular facilities, process or technologies. A compressive audit provides a detailed energy project implementation plan for a facility. This type of audit offers the most accurate estimate of energy savings and cost.

Q.1(e) Define following terms : [4]

- (i) Solar altitude
- (ii) Solar Azimuth angle
- (iii) Day length
- (iv) Local solar time

(A) (i) Solar altitude (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

(ii) Solar Azimuth angle (γ) : It is the angle of deviation of the normal to the surface from the local meridian, the zero point being south, east positive and west negative.

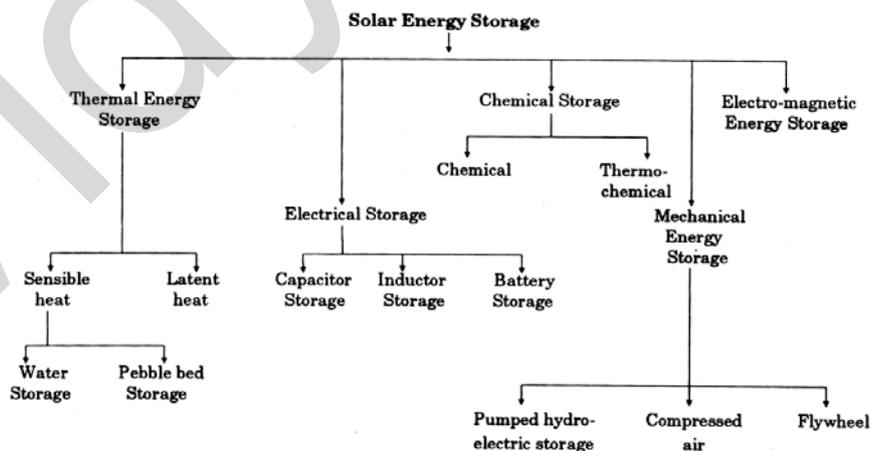
(iii) Day length (t_d) : It is the time elapsed between sunrises to sunset. By knowing the values of sunrise and sunset hour angle, we can calculate the day length.

(iv) Local solar time (LST) : This is also called as Local Apparent time(LAT). The time so calculated is (LST).

$$(LST) = IST \pm (\text{Standard time longitude} - \text{longitude of location}) + \text{Equation of time correction}$$

Q.1(f) Give classification of Solar Energy Storage System. List two applications of thermal storage. [4]

(A)



Application of thermal storage.

- (i) Solar water heater
- (ii) Solar space heating

Q.2 Attempt any FOUR of the following :

[16]

Q.2(a) List main considerations in selection of site for hydro-electric power plant.

[4]

(A) Criteria for site selection of small hydro electric power plant.

- (i) Water availability and method of storage.
- (ii) Availability of head.
- (iii) Distance of power station from power demand centre.
- (iv) Availability of construction materials.
- (v) Access to site.
- (vi) Availability of transport facilities etc.
- (vii) Availability of labour power.
- (viii) Heavy rain fall area.

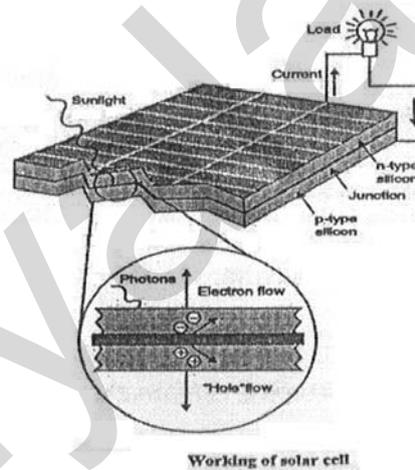
Q.2(b) Describe the principle of solar photovoltaic energy conversion.

[4]

(A) Principles of photovoltaic power generation

Photovoltaic electric 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.
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.



Main elements of SPV :

- (i) Photovoltaic array
- (ii) Inverter
- (iii) Energy storage
- (iv) System charge control
- (v) Balance of system (BOS) components

Q.2(c) Describe a passive solar space heating system.

[4]

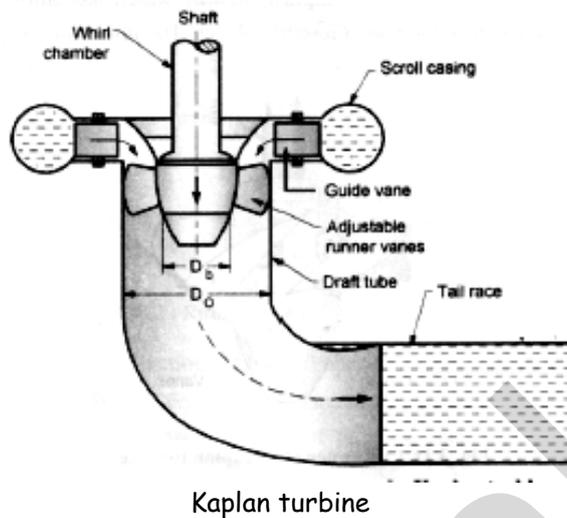
(A) Passive solar space heating system

This system has south facing concrete or stone or brick wall 10 cms to 20 cm thick called trombay wall. It is designed for thermal storage and its outer surface painted black. The wall is covered by sheets of glass. It is provided with vents A and B at top and bottom for circulation of hot air and cold air. Radiations are absorbed by wall and air in the gap gets heated and flows from top and bottom. The living space gets energy transfer by radiation. Campers are provided at the top of glass covers to allow the excess heat to escape to the surroundings when the heating is not required.

Q.2(d) Explain in brief with neat sketch the working of Kaplan turbine. [4]

(A) **Kaplan turbine:**

IT is a axial flow reaction turbine in which water flows parallel to the axis of shaft. It has a vertical hollow shaft which is enlarged at the bottom in the shape of propeller called hub or boss. The vanes are fixed on the hub which acts as the runner of the Kaplan turbine. It has scroll casing guide mechanism and draft tube.



Q.2(e) What is energy plantation? Give its four advantages. [4]

(A) **Energy Plantation**

There are certain plants which can be planted and harvested over regular period of time to have high yield per unit area. Thus the method of tapping maximum solar energy by growing plants on large scale is called energy plantation.

Advantages

- (i) Virtually there is no maintenance
- (ii) It is economical.
- (iii) It is non polluting.
- (iv) It acts as a best solar collector.

Q.2(f) Explain how Green House gases and Global Warming is affecting the climate change. [4]

(A) **Effect 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.

Global Warming

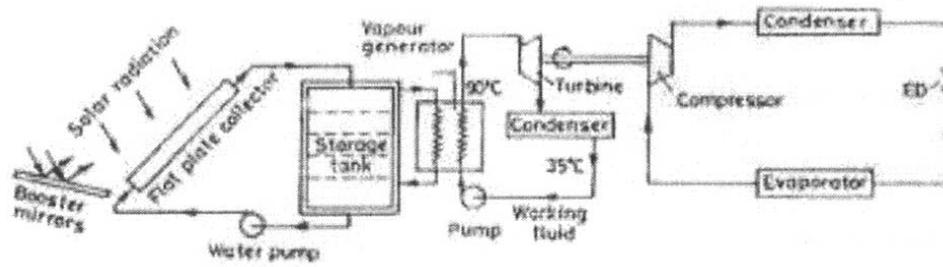
It is also called as climate change. It refers to the long term fluctuations in temperature, prediction, wind and earth elements of the earth climate system.

Q.3 Attempt any FOUR of the following : [16]

Q.3(a) Draw neat sketch of solar refrigeration system. [4]

(A) 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.



Q.3(b) Distinguish between concentrating and non-concentrating solar collectors. [4]

(A)

	Concentrating solar collector	Non-Concentrating solar collector
(i)	It is the most powerful type of collector.	It is less efficient solar collector
(ii)	Fluid temperatures up to around 5000°C can be achieved.	Maximum Temperature of fluid is 300°C
(iii)	It can be used in solar furnaces and solar power plants.	It can be used in water heating.
(iv)	More initial cost	Less initial cost.

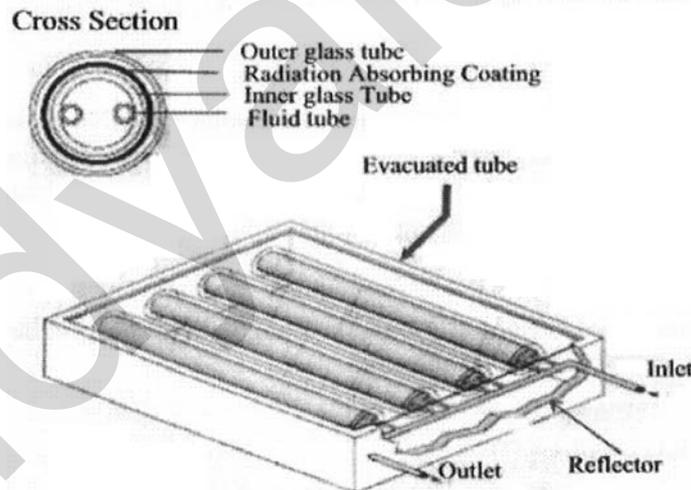
Q.3(c) Describe the solar evacuated flat plate collector. State two advantages of its over simple solar flat plate collector. [4]

(A) **Solar Evacuated Tube flat plate collector : (ETC)**

ETC evacuated tube solar collectors convert energy from the sun into usable heat in a solar water heating system. This energy can be used for domestic and commercial hot water heating, pool heating, space heating or even air conditioning.

Construction:

The ETC solar collector is comprised of four main parts :



Evacuated Tube (ET) : Absorbs solar energy and converts it to usable heat. A vacuum between the two glass layers insulates against heat loss.

The Heat Transfer Fin helps to transfer heat to the Heat Pipe.

Heat Pipe (HP) : Copper vacuum pipe that transfers that heat from within the ET up to the manifold.

Manifold : Insulated box containing the copper header pipe. The header is a pair of contoured copper pipes with dray connect sockets that the heat pipes plug into.

Mounting Frame : Strong and easy to install with a range of attachment options.

Advantages of Solar Evacuated Tube collector : (ETC) over flat plate collector:

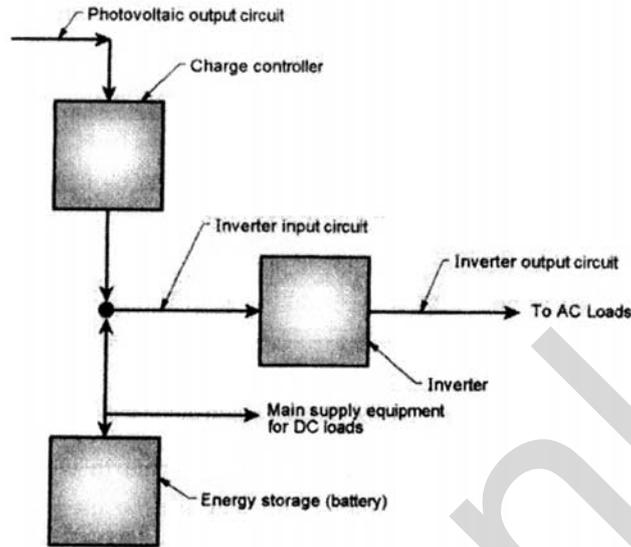
- (i) It absorbs direct, diffused and reflected components of solar radiations.
- (ii) It is fixed in the orientation thus there is no need for tracking.
- (iii) It has low cost and it is almost maintenance free.

Q.3(d) Describe the layout and working of a stand alone Solar Photovoltaic Power Plant. [4]

(A) Stand alone solar photovoltaic power plant/system

Salient features of system are

- Power supply to the system independently without common grid. Operate independently.
- Used for backup power when connecting to grid is very costly.
- Hybrid stand alone may include other power producing devices for backup.
- Various types are direct coupled, with battery storage, hybrid etc.

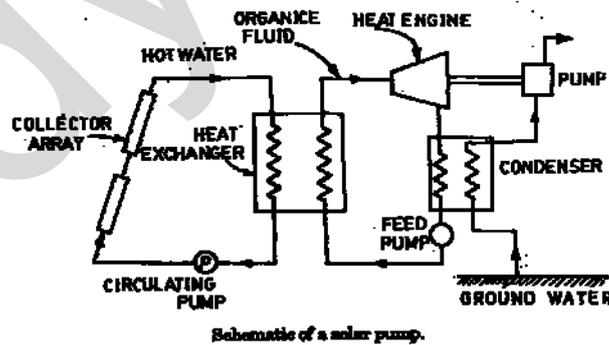


Q.3(e) Draw neat sketch of solar pump system. State functions of each components. [4]

(A) Solar pump system : Solar pumping consists of power generated by solar energy for water pumping useful for irrigation.

The basic system consists of following components:

- Solar collectors may be Flat plate or sun tracking concentrators
- The heat transport system
- Boiler or heat exchangers
- Heat Engine : Rankine/ Stirling hot gas, rotary piston
- Condenser
- Pump may be Reciprocating, centrifugal, diaphragm



Schematic of a solar pump.

Q.3(f) Distinguished between biomass and biogas. [4]

(A)

	Biomass	Biogas
(i)	Biomass is the amount of living matter.	Biogas is created by fermenting biomass.
(ii)	Biomass is the organic matter.	Biogas is a mixture of gases.
(iii)	It is a solid fuel.	Biogas is a gas fuel (mixture of methane and carbon).
(iv)	Biomass is obtained from solar energy.	Biogas is obtained by degradation of animal waste or plants i.e. from Biomass.
(v)	Example - cow dung, wood	Example - Methane

Q.4 Attempt any FOUR of the following :

[16]

Q.4(a) Explain Yaw mechanism in wind mill. State its importance.

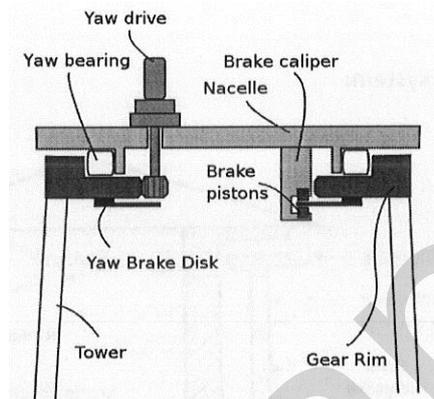
[4]

(A) Yaw mechanism in wind mill

Each yaw drive consists of powerful electric motor (usually AC) with its electric drive and a large gearbox, which increases the torque.

A yaw control mechanism is provided to adjust the nacelle around vertical axis to keep it facing the wind. In small windmills a flap or tail vane is provided on the nacelle for automatic positioning of turbine axis. In large windmills servo mechanism mechanism alongwith wind direction sensors are provided.

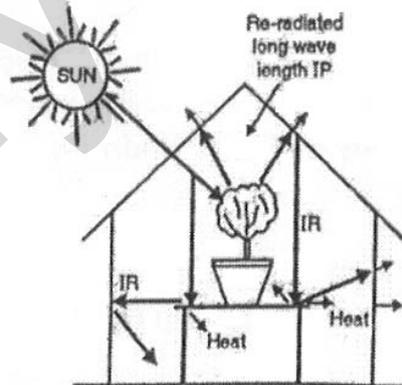
Importance : To ensure the wind turbines is producing the maximum amount of electrical energy at all times, the yaw drive is used to keep the rotor facing into facing into the wind as the wind direction changes.



Q.4(b) What is global warming?

[4]

(A) **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. Carbondioxide produced by power plants has no ill effect on human life but increase concentration of CO_2 leads to climate change, it increases heat trapping quality leading to green house effect. Heating of earths atmosphere due to this trapping is due to long wavelength infrared radiations by the CO_2 layer in the atmosphere. This effect is used in growing the green plants in an enclosure made of glass and other transparent material so that heat is trapped in cold atmosphere even.



Q.4(c) What is energy conservation? List the ways to improve boiler efficiency.

[4]

(A) Energy conservation means reduction in energy consumption, without masking any sacrifice of quantity and quality of production. In the same energy consumed, higher production is done. it is not fixing the limit of consumption qualitatively or quantitatively but insist the use efficiently thus decreasing the cost of your production to some extent by the way of reduction in the energy bill.

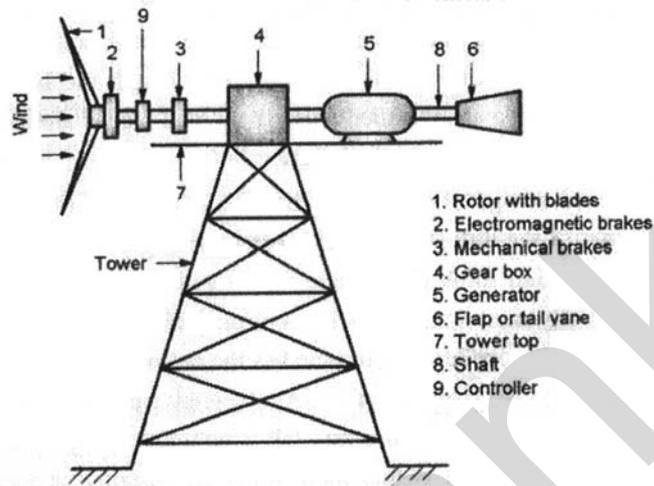
Ways of improving boiler efficiency

- Reducing excess air
- Installing economizer
- Reducing blow down
- Recovering waste heat from blow down

- Stopping dynamic operation
- Reducing boiler pressure
- Operating at peak efficiency
- Preheating combustion air
- Switching from steam to air atomization
- Switching to lower cost fuel

Q.4(d) Sketch the diagram of a Horizontal Axis Wind turbine and explain the functions of its main components. [4]

(A) Horizontal Axis wind turbine



Wind mill : Basic structure of windmill consists of the following components.

- Rotor blades** : The rotor blades extract the wind energy and converts it into rotational form
- Gearbox** : It converts the rotational speed from low speed shaft and transforms it into rotation on the high speed shaft.
- Hub** : It is the connection point for the rotor blades and low speed shaft.
- Mechanical brake** : It is a disc brake used for repairs and maintenance of the wind mill.
- Generator** : It converts the rotational speed of high speed shaft to electrical energy.
- Yaw mechanism** : This mechanism keeps the rotor blades parallel to the flow of wind .
- Anemometer and wind vane** : They are the instruments for measuring wind speed.

Q.4(e) Define : (i) Pyrolysis (ii) Fermentation [4]

(A) (i) Pyrolysis

It is the heating of biomass in a closed vessel at temperatures in the range of 500° C to 900° 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.

(ii) Fermentation

Fermentation is a process of decomposition of complex molecules of organic compound under the influence of micro organism (ferment) such as yeast, bacteria, enzymes etc.

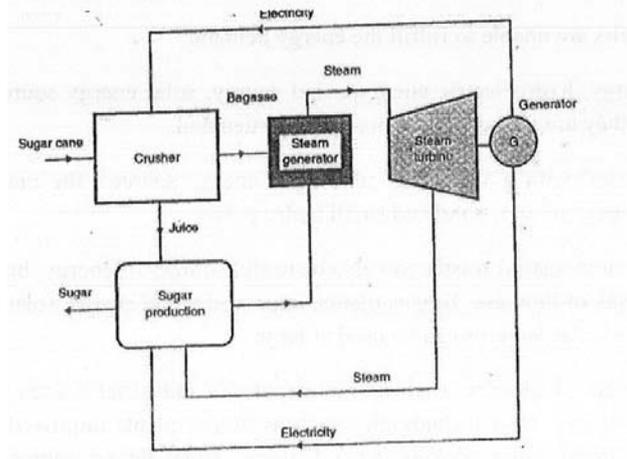
Q.4(f) Explain co-generation in sugar factory with neat sketch. [4]

(A) Co-generation process in Sugar factory

Co generation in Sugar factory

In sugar factory juice is extracted from cane and bagasses are burnt to generate steam. This steam is send to steam turbine to generate electricity. Extracted steam and low pressure steam from turbine is used in the process of sugar manufacturing.

In this way both electricity and steam, generated and used at the same place hence overall efficiency is increased.



Co generation in Sugar factory

Q.5 Attempt any FOUR of the following :

[16]

Q.5(a) Explain the process of production of biodiesel.

[4]

(A) **Biodiesel Transesterification** : Biodiesel is an alternative diesel fuel. Vegetable oil is too thick to flow through modern diesel engines without causing damage, so we can lower its viscosity through a process called Transesterification.

Transesterification is the chemical process which replaces one type of alcohol for another in an ester. An ester is made by combining an alcohol with an acid.

Vegetable oil is an ester of glycerol with long chain fatty acids. The formula for vegetable oil is $C_3H_5(RCOOH)_3$, with the fatty acids represented by $RCOOH$ attached to a glycerol ($C_3H_5(OH)_3$) molecule. Examples of fatty acids are Stearic acid, Palmitic acid, Linoleic acid, and Oleic acid. Methanol (CH_3OH) is used to replace glycerol ($C_3H_5(OH)_3$). A strong alkali is used as a catalyst to break apart the fatty acids from the glycerol. In commercial production we typically see Sodium Methylate (CH_3NaO) dissolved in methanol used as the catalyst.

The chemical formula for biodiesel transesterification is : $C_3H_5(RCOOH)_3 + 3CH_3H \leftrightarrow 3RCOCH_3O + C_3H_5(OH)_3$

The biodiesel transesterification process is slightly reversible making it difficult to get 100% conversion. To push the reaction to its most complete status we use LeChetelie's Principle and offset the reactants to drive the reaction in a more favorable direction.

Q.5(b) Write down detailed energy audit methodology.

[4]

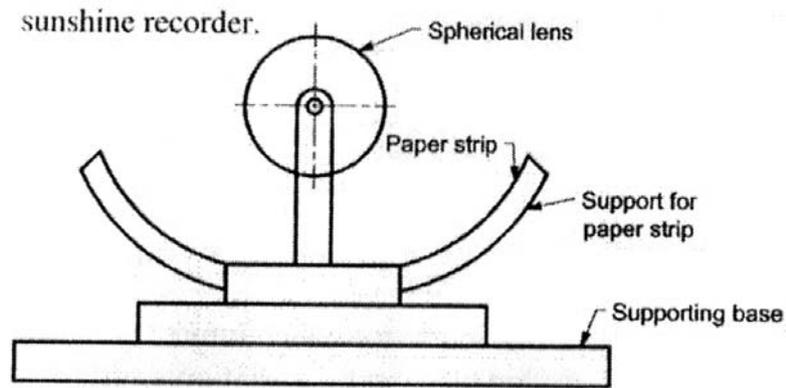
(A) **Detailed Energy Audit Methodology** : It is a comprehensive analysis of an energy project and offers the accurate estimate of energy savings and cost. It covers the detailed study of present energy consumption, the use of energy for various processes with calculations of energy efficiency and to 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 :

- (i) Details about plant
- (ii) Description of production processes involved
- (iii) Description of energy and utility system
- (iv) Detailed process flow diagram and energy
- (v) Calculation of energy efficiency and process systems
- (vi) Recommendations for energy conservation

Q.5(c) Describe the construction and principle of operation of a sunshine recorder. [4]

(A) Sunshine recorder



A sunshine recorder is a device that records the amount of sunshine at a given location. The results provide information about the weather and climate as well as the temperature of a geographical area. This information is useful in meteorology, science, agriculture, tourism, and other fields. It has also been called a heliograph.

There are two basic types of sunshine recorders. One type uses the sun itself as a time scale for the sunshine readings. The other type uses some form of clock for the time scale.

A campbell-Stokes sunshine recorder concentrates sunlight through a glass sphere onto a recording card placed at its focal point. The length of the burn trace left on the card represents the sunshine duration. A homogenous transparent glass sphere L is supported on an arc XY , and is focused so that an image of the sun is formed on recording paper placed in a metal bowl FF' attached to the arc. The glass sphere is concentric to this bowl, which has three partially overlapping grooves into which recording cards for use in the summer, winter or spring and autumn are set.

Three different recording cards are used depending on the season. The focus shifts as the sun moves, and a burn trace is left on the recording card at the focal point. A burn trace at a particular point indicates the presence of sunshine at that time, and the recording card is scaled with hour makes so that the exact time of sunshine occurrence can be ascertained. Measuring the overall length of burn traces reveals the sunshine duration for that day. For exact measurement, the sunshine recorder must be accurately adjusted for planer leveling, meridional direction and latitude.

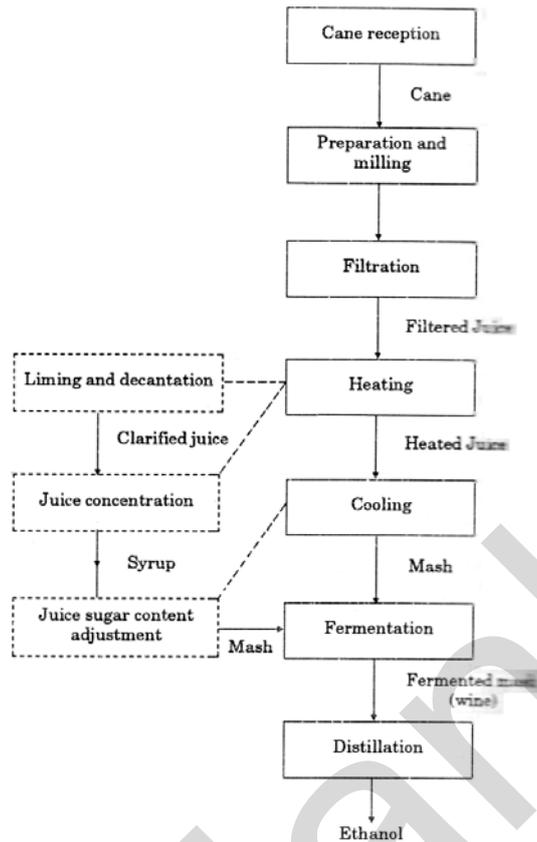
Q.5(d) Compare small & mini hydroelectric plant. [4]

(A)

	Small hydroelectric plants	Mini hydroelectric plants
(i)	Water head ranges upto 30 mts.	Water head ranges between 5 to 20 mts.
(ii)	Can be built on small dams.	Can be built along the stream of the river.
(iii)	Capital cost per KW is less.	Capital cost per KW is high.
(iv)	Longer time for construction.	Shorter time for construction.

Q.5(e) Draw flow diagram of production of ethanol from sugar cane. [4]

(A) Production of ethanol from sugar cane



Q.6 Attempt any FOUR of the following : [16]

Q.6(a) List the instruments used to recover waste heat. Explain any one in detail. [4]

(A) Instruments used to recover waste heat are :

- (i) Recuperator
- (ii) Regenerator
- (iii) Economizer
- (iv) Heat pipe
- (v) Inceneters, etc

Recuperator : In a recuperator, heat exchange takes place between the flue gases and the air through metallic or ceramic walls. Duct or tubes carry the air for combustion to be pre-heated, the other side contains the waste heat stream. A recuperator for recovering waste heat from flue gases is shown in figure. The simplest configuration for a recuperator is the metallic radiation recuperator, which consists of two concentric lengths of metal tubing as shown figure.

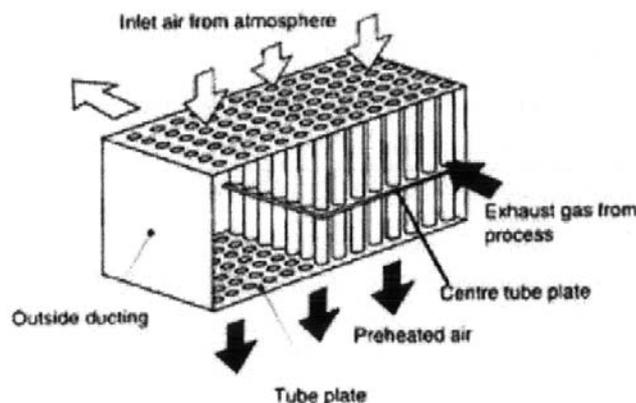


Figure- Recuperator

Regenerator : The Regeneration which is preferable for large capacities has been very widely used in glass and steel melting furnaces. Important relations exist between the size of the regenerator, time between reversals, thickness of brick, conductivity of brick and heat storage ratio of the brick. In a regenerator, the time between the reversals is an important aspect. Long periods would mean higher thermal storage and hence higher cost. Also long periods of reversal result in lower average temperature of preheat and consequently reduce fuel economy. Accumulation of dust and slagging on the surfaces reduce efficiency of the heat transfer as the furnace becomes old.

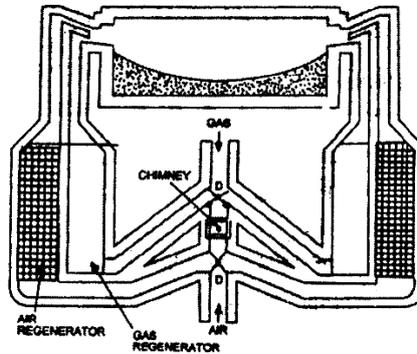


Figure -Regenerator

Heat pipe : The Heat Pipe comprises of three elements – a sealed container, a capillary wick structure and a working fluid. The capillary wick structure is integrally fabricated into the interior surface of the container tube and sealed under vacuum. Thermal energy applied to the external surface of the heat pipe is in equilibrium with its own vapour as the container tube is sealed under vacuum. Thermal energy applied to the external surface of the heat pipe causes the working fluid near the surface to evaporate instantaneously. Vapour thus formed absorbs the latent heat of vaporization and this part of the heat pipe becomes an evaporator region. The vapour then travels to the other end the pipe where the thermal energy is removed causing the vapour to condense into liquid again, thereby giving up the latent heat of the condensation. This part of the heat pipe works as the condenser region. The condensed liquid then flows back to the evaporated region.

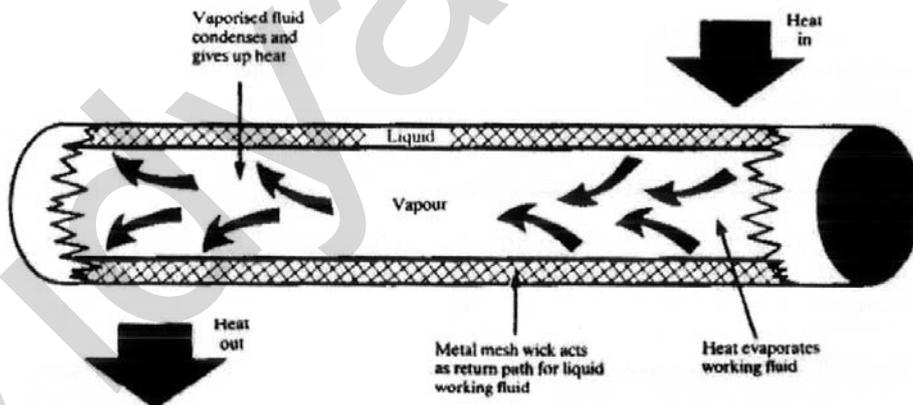


Fig-heat pipe

Q.6(b) Describe the working principle of infrared thermometer. [4]

(A) **Infrared thermometer** : An infrared thermometer is a thermometer which infers temperature from a portion of the thermal radiation sometimes called blackbody radiation emitted by the object being measured. They are sometimes called laser thermometers if a laser is used to help aim the thermometer, or non-contact thermometers or temperature guns, to describe the device's ability to measure temperature from a distance. By knowing the amount of infrared energy emitted by the object and its emissivity, the object's temperature can often be determined. Infrared thermometers are a subset of devices known as "thermal radiation thermometers".



The design essentially consists of a lens to focus the infrared thermal radiation on to a detector, which converts the radiant power to an electrical signal that can be displayed in units of temperature after being compensated for ambient temperature. This permits temperature measurement from a distance without contact with the object to be measured. A non-contact infrared thermometer is useful for measuring temperature under circumstances where thermocouples or other probe-type sensors cannot be used or do not produce accurate data for a variety of reasons.

Q.6(c) State concept of waste heat recovery system. Draw a labelled schematic of any waste heat recovery system. [4]

(A) Boiler Efficiency and furnace efficiency

The term boiler efficiency is often substituted for combustion or thermal efficiency. True boiler efficiency is the measure of fuel to steam efficiency. Basically Boiler efficiency can be tested by the following methods:

- (i) The Direct Method : Where the energy gain of the working fluid (water and steam) is compared with the energy content of the boiler fuel.
- (ii) The Indirect Method : Where the efficiency is the difference between the losses and the energy input.

The direct method is also known as 'input-output method' due to the fact that it needs only the useful output (steam) and the heat input (i.e. fuel) for evaluating the efficiency. This efficiency can be evaluated using the formula:

$$\text{Boiler Efficiency} = \frac{\text{Heat Output}}{\text{Heat Input}} \times 100$$

$$\text{Boiler Efficiency} = \frac{\text{Steam flow rate} \times (\text{steam enthalpy} - \text{feed water enthalpy})}{\text{Fuel firing rate} \times \text{Gross calorific value}} \times 100$$

Let m_s = Rate of steam generated kg per hour

h_1 = Enthalpy of steam at the exit of boiler in kJ/kg

h_2 = Entahlp of feed water in

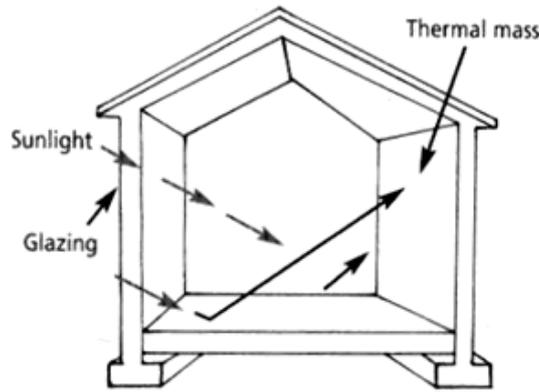
m_f = rate of fuel consumed in kg / hr

G.C.V. = Gross calorific Value in kJ/kg

$$\eta = m_s(h_1 - h_2)/m_f \times G.C.V$$

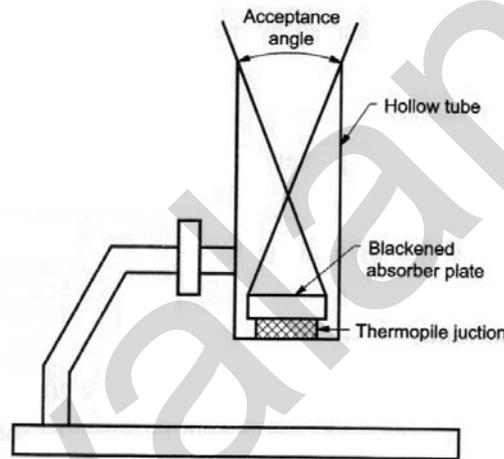
Q.6(d) Draw the sketch of solar space heating and hot water system. [4]

(A) 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



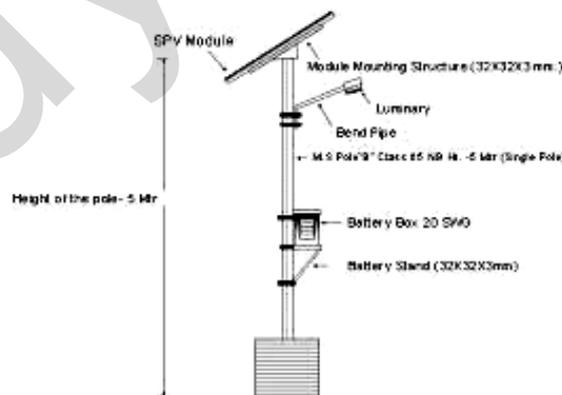
Q.6(e) Explain with help of sketch working of Pyrheliometer. [4]

(A) **Pyrheliometer** : It measures the beam radiations only coming from the Sun. The hollow receiver tube can be tilted about an axis perpendicular to its length. Thus the tube can be made to face the sun, thereby receiving only the beam radiation. No diffuse radiation can enter the tube. When the radiation falls on the absorber plate, it absorbs the radiation and it gets heated up, thereby raising its temperature. The rise in temperature is measured by measuring the thermo emf of the thermopile.



Q.6(f) Describe the SPV solar street light. [4]

(A)



SPV Solar Street light: Solar cells are often electrically connected and encapsulated as a module. SPV modules have a sheet or glass on the front side allowing light to pass while protecting semiconductor wafers from the rain hail etc. Modules are then connected in series or parallel both to create an array. The power output of the array is measured in Watts.

