



SUMMER – 13 EXAMINATION

Subject Code: **12244**

Model Answer

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.



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Q.No. 01 a)

i) (02 marks for definition and 02 marks for classification)

Energy: Energy is capacity to do work. Energy is the primary and most universal measure of all kinds of work by human beings and nature.

Energy is classified into several types based on the following criteria.

- a) Primary and Secondary energy
- b) Commercial and Non commercial energy
- c) Renewable and Non Renewable energy

ii) (Half mark for each correct list)

List of Any four energy sources

Primary Energy sources : a) Crude oil b) hard coal c) natural gas d) cooking coal e) fuel wood
f) Nuclear energy

Secondary Energy sources : a) petroleum products b) coke-oven coke c) Charcoal d) Solar energy e) Wind energy f) Geothermal energy

iii) (02 marks for definition and 02 marks for examples)

Renewable energy sources: It is energy that comes from resources which are continually replenished . .They are not exhaustible and clean in nature.

Examples a) Solar b) Wind c) Tidal d) Geothermal (Any two)

Non renewable energy Sources: It is the energy that comes from resources which are exhaustible. Once it is used it vanishes Mostly these comes out of the ground as liquids , gases and solids.

Example : a) Coal b) crude oil c) Liquefied Petroleum Gas (LPG) c) Nuclear Energy (Any two)



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iv) (02 marks for name and 02 marks for factors)

Commonly used utilities are: a) Steam b) compressed air c) electricity d) water

Final cost of steam depends on fuel type, unit fuel cost, boiler efficiency, feed water temperature and steam pressure

Q.No. 01 b)

i) (02 marks for each definition and 02 marks for geometry)

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

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.

Components of solar radiation geometry: (Any four)

a) The hour angle (ω) b) the declination angle (δ) c) Latitude angle (ϕ) d) The solar altitude angle (α) e) Solar azimuth angle (A) f) Solar incidence angle (θ)

ii) (03 marks for definition and 03 marks for process)

Transesterification process of biodiesel production :

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.



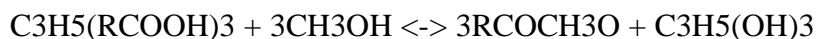
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Vegetable oil is an ester of glycerol with long chain fatty acids. The formula for vegetable oil is $C_3H_5(RCOOH)_3$, with the fatty acids represented by $RCOOH$ attached to a glycerol ($C_3H_5(OH)_3$) molecule. Examples of fatty acids are Stearic acid, Palmitic acid, Linoelic 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:



Q.No. 02 a) (02 marks for definition and 02 marks for composition)

Solar constant: The rate at which solar energy arrives at the top of the atmosphere is called the solar constant I_{sc} . This is the amount of energy received in unit area perpendicular to the sun's direction at the mean distance of the earth from the sun. The solar constant includes all types of solar radiation not just the visible light.

Composition of solar radiation :

- a) Ultraviolet C or UVC : It varies in a range of 100 to 280 nm and is at higher frequency than light. It has germicidal properties
- b) Ultraviolet B or UVB : It ranges over a span of 280 to 315 nm and is mostly absorbed by atmosphere. It is responsible for the photochemical reaction leading ozone layer production.
- c) Ultraviolet A or UVA : It ranges from 315 to 400 nm and is less damaging to the DNA. It is used in tanning and PUVA therapy for psoriasis
- d) Visible range or light : It spans over 400 to 700 nm and is visible .
- e) Infrared : It ranges over a span of 700 to 1060 nm and is responsible for the warmth.

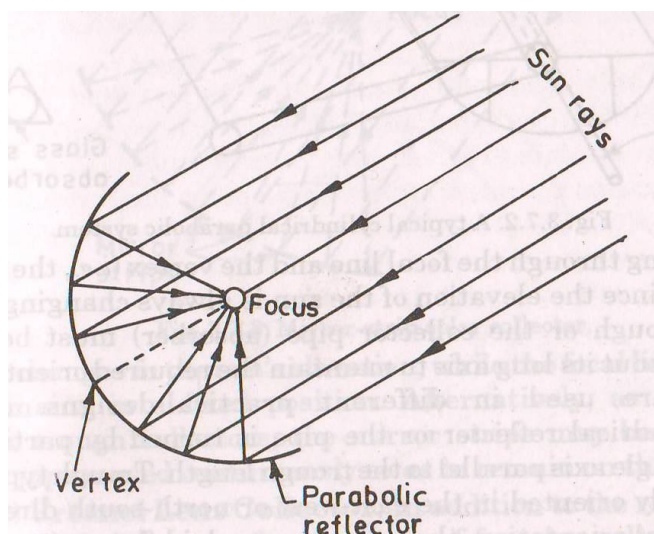
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Q.No. 02 b) (02 marks for explanation and 02 marks for sketch)

Parabolic trough collector: The principle of Parabolic Trough collector is shown in the figure. Solar radiation coming from the particular direction is collected over the area of the reflecting surface and is concentrated at the focus of the parabola, if the reflector is in the form of trough with parabolic cross section; the solar radiation is focused along a line. The absorber is kept along focus axis, which is a collector pipe with a selective absorber coating. The trough is usually aligned on a north south axis. Heat transfer fluid runs through the tube to absorb the concentrated sunlight.



Parabolic trough collector

Q.No. 02 c) (04 marks for complete derivation)

Expression for power in wind:

Kinetic Energy of object (Wind) = KE

$$KE = \frac{1}{2} MV^2 \text{ ----- (1)}$$

Where M= Total mass

V= Velocity

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The amount of air passing in unit time, through an area A, with velocity V is equal to AV and its mass m is equal to its volume multiplied by the density of the air

$$m = \rho \times A \times V$$

From (1)

$$KE = \frac{1}{2} m V^2$$

$$KE = \frac{1}{2} (\rho \times A \times V) V^2$$

$$KE = \frac{1}{2} (\rho A v^3) J$$

But Power = Energy / Time

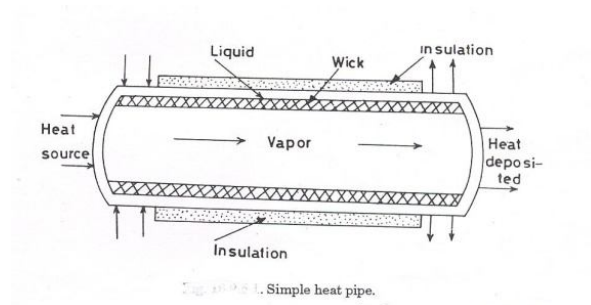
$$P = \frac{1}{2} (\rho A v^3) \text{ Watts}$$

Q.No. 02 d) (02 marks for description and 02 marks for sketch)

Heat pipe :

Heat pipe is tube containing vapor with the condensate recycled by a wick and offers an effective conductivity much greater than that of copper. Usually heat pipe is a means for transporting heat efficiently from a source to a cooler receiver by utilizing the latent heat of vaporization of a liquid. A heat pipe is a closed space containing a suitable working liquid and its vapor. One part of the space is in contact with the heat source and with the cooler material to which the heat is to be transported. The interior wall of the space is lined with a porous material called a wick.

In the hotter part of the heat pipe, the working fluid is vaporized thereby taking up the latent heat of vapourisation. The vapour diffused towards the cooler region because the pressure is lower there & condensed to liquid. In doing so it deposits the heat of vaporization taken up from the source. The liquid is returned to the heat source region by capillary action of the wick. There is thus a continuous movement of vapour from the heat source to the receiver and of condensed liquid back to the source, accompanied by the transfer of heat.



Heat Pipe



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Q.No. 02 e) (02 marks for definition and 02 marks for list)

Energy Audit : An energy audit is a step in an energy management programme. It shows how efficiently energy is being used and highlights opportunities for energy cost saving and show ways to improve productivity

Instruments used for energy Audit:

- i) Electrical measuring instruments
- ii) Combustion analyzer
- iii) Thermometer
- iv) Infrared thermometer
- v) Flow meter
- vi) Leak detector
- vii) Lux meter

Q.No. 02 f) (02 marks for description and 02 marks for sketch)

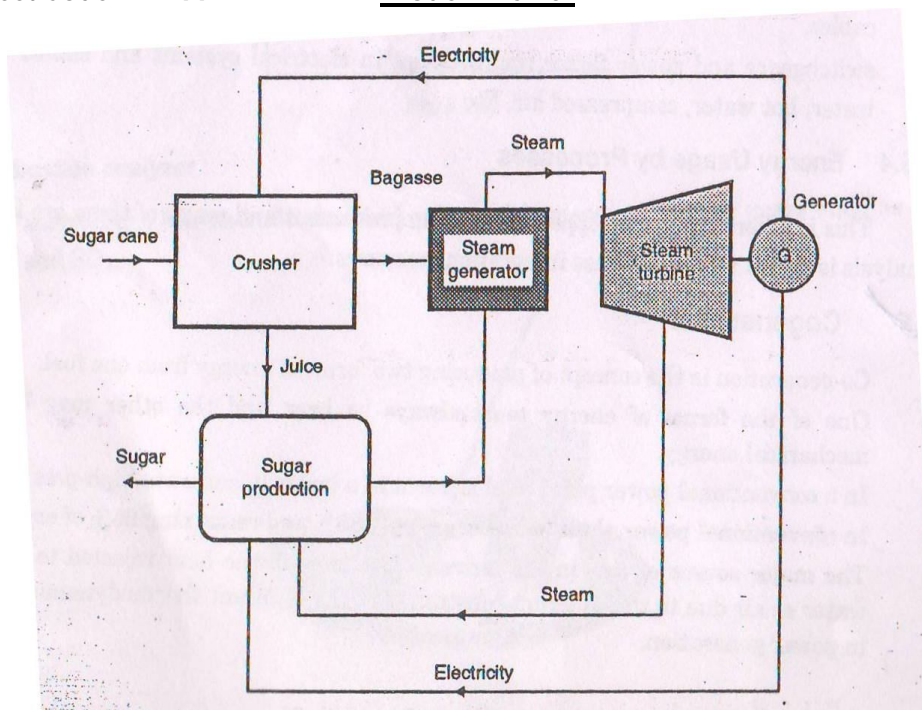
Co generation Co-generation is procedure for generating electric power and useful heat in a single installation. The useful heat may be in the form of steam, hot water, or hot air. In the cogeneration system, a mechanical work is converted into electrical energy in an electric generator and the discharged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

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

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Q.No. 03 a) (04 marks for description)

Principle of energy conversion: Atmospheric winds are formed due to uneven solar heating and the rotation of the earth which accelerates the air. Winds transfer atmospheric energy to offset uneven solar heating. Breezes are the effect of quick heating of land than sea water. Wind energy is the kinetic energy associated with the movement of atmospheric air. The kinetic energy of the wind is transferred through blades of wind generator into mechanical energy and drives the shaft of generator which generates electricity. The energy depends on wind speed, density of the air which is the effect of temperature, barometric pressure and altitude.

Q.No. 03 b) (02 marks for description and 02 marks for sketch)

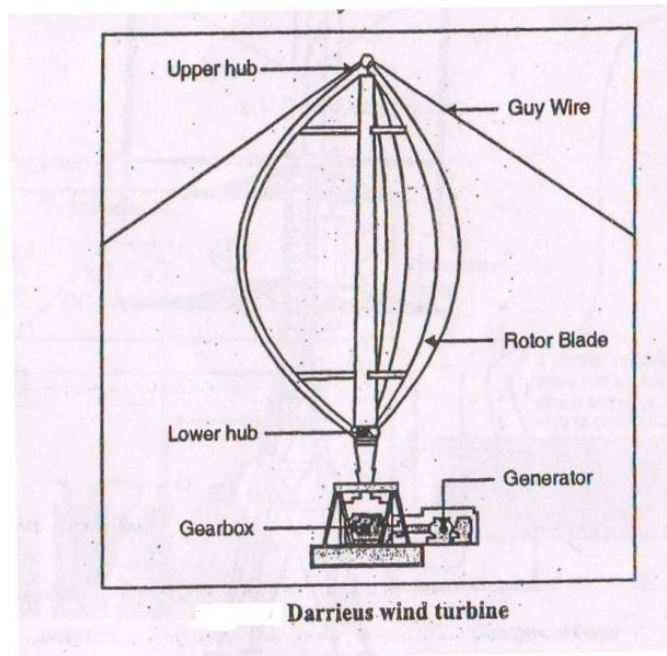
Darrieus Vertical axis wind turbine:

It is a Vertical Axis Wind Turbine (VAWT). It has good efficiency, but produce large torque ripple and cyclic stress on the tower, which contributes to poor reliability. Also they generally require some external power source or an additional savonius rotor to start turning because the starting torque is very low

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Q.No. 03 c) (02 marks for definition and 02 marks for methods)

Biomass: Biomass is organic matter produced by plants, both terrestrial and aquatic and their derivatives. Biomass is a renewable energy source because we can always grow more trees and crops and waste will always exist. Wood, crop, manure and garbage are the fuel for biomass.

Energy from biomass can be obtained by the following methods

- i) Briquetting or Pelleting of solid Biomass
- ii) Combustion
- iii) Pyrolysis
- iv) Gasification
- v) Anaerobic Digestion.

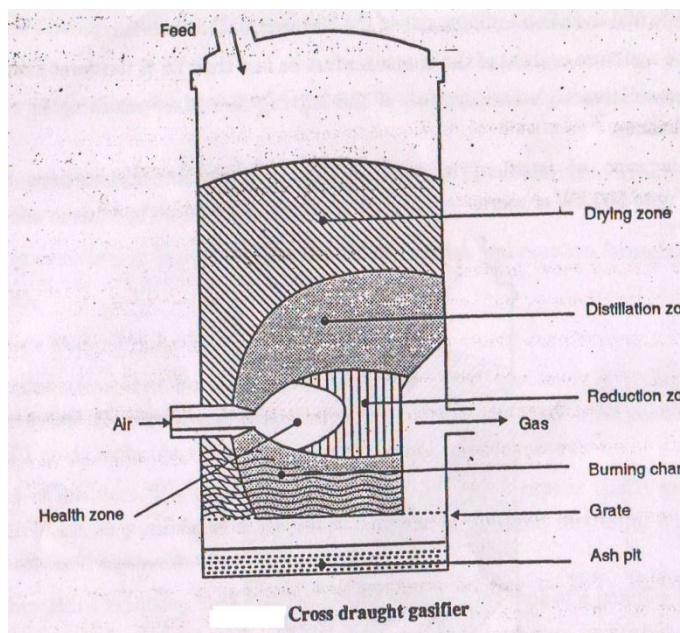
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Q.No. 03 d) (02 marks for description and 02 marks for sketch)

Cross Draught Gasifier: Cross draught gasifiers are used for gasification of charcoal. It results in very high temperature (more than 1500°C) in the heart zone . It can be used for small scale. It has a cyclone and a bed filter. It has minimum tar converting capability, resulting in the need for high quality charcoal



Q.No. 03 e) (02 marks for definition and 01 mark each for advantage and limitation)

Payback period:

The payback period, in business and economics refers to the period of time required for the return on an investment to repay the sum of the original investment. It initially measures how long something takes to pay for itself. Shorter payback periods are obviously preferable to longer payback periods.



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The simple payback period is usually calculated as follows :

$$\text{Simple payback period (years)} = \frac{\text{Capital cost of the project (in Rs.)}}{\text{Net Annual savings (in Rs.)}}$$

OR

$$\text{Simple payback period} = \frac{\text{First cost}}{\text{Yearly benefits} - \text{Yearly costs}}$$

Advantages:

- i) It is simple in concept and application.
- ii) It does not use tedious calculations.
- iii) It favors projects, which bring substantial cash inflows.

Limitations:

- i) It fails to consider the time value of money.
- ii) It is carried out without discounting/ compounding.
- iii) It ignores cash flows beyond the payback period.

Q.No. 04 a) (01 marks for each difference , any four)

i) Differences between renewable and non renewable energy sources

Sr. No	Non Renewable sources	Renewable sources
01	These sources are used for mass generation of power	These sources are used for power in less magnitude
02	These sources generates pollution	These sources will not generates pollution
03	Initial investment cost is more	Initial investment cost is more but sources are free of cost
04	Use of conventional fuels like coal, petrol, diesel, nuclear etc	No fuel is used
05	More frequently used all over the world	Becoming famous now a days
06	These sources may be finished in coming years	These sources are inexhaustible
07	Example : Thermal, Hydro, nuclear etc	Example : Solar, Wind tidal etc



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ii) (04 marks for appropriate answer)

Importance of alternate energy sources:

In 2006, about 18% of global energy consumption came from renewable, out of which 13% from biomass and wood burning. Next renewable, hydropower was 3%. The technical potential for alternate energy sources is very large. India is blessed with a variety of renewable energy sources. Municipal and industrial waste can also be useful sources of alternate energy. As a result of technology improvement, biogas, wood stoves, solar water heaters, solar cookers, solar lanterns, street lights, pumps, wind electric generator etc are becoming popular.

iii) (02 marks for description and 02 marks for sketch)

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 .

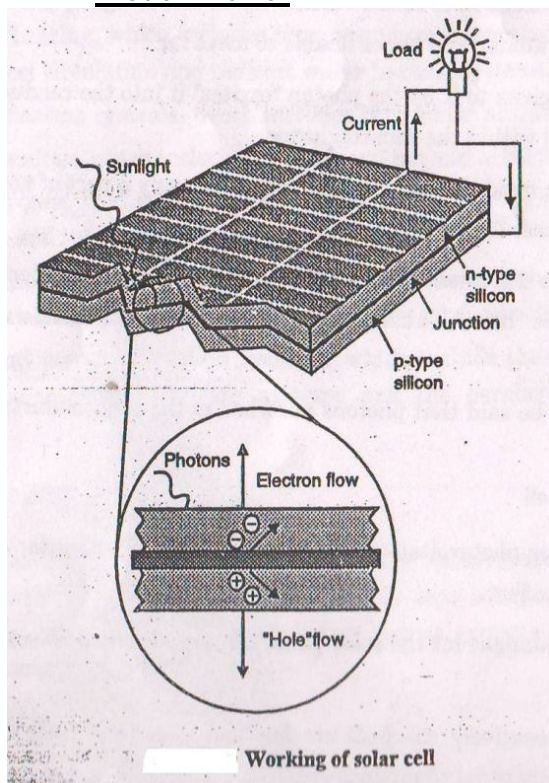
Photovoltaic cell: A solar cell or photovoltaic cell is a device that converts solar energy into electricity by the photovoltaic effect. Photons in sunlight hit the solar panel and are absorbed by semiconducting materials such as silicon.

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.

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iv) (04 marks for description)

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.

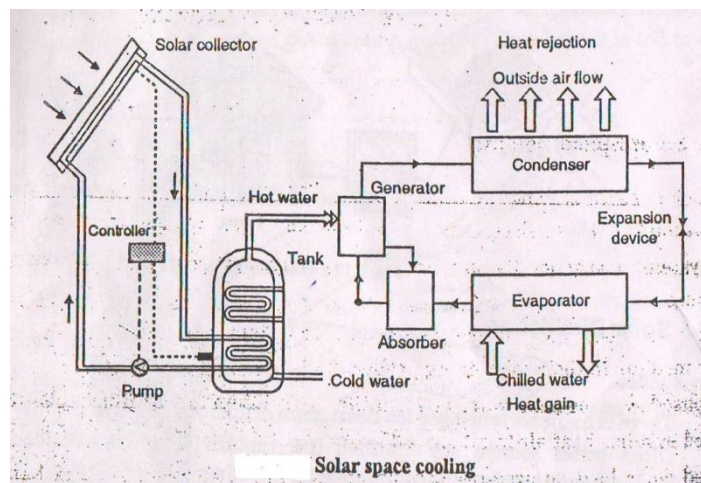
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Q.No. 04 b) i) (03 marks for description and 03 marks for sketch)

Solar space cooling: Figure shows solar space cooling. In the chiller refrigerant vapor from the evaporator is absorbed by a solution mixture in the absorber which is then pumped to the generator. The refrigerant is then revaporizes using a waste steam heat source. The refrigerant then returns to the absorber through a throttling valve. Heat is provided ion the system is by solar collector in the form of hot water



Q.No. 04 b) ii) (03 marks for description and 03 marks for sketch)

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

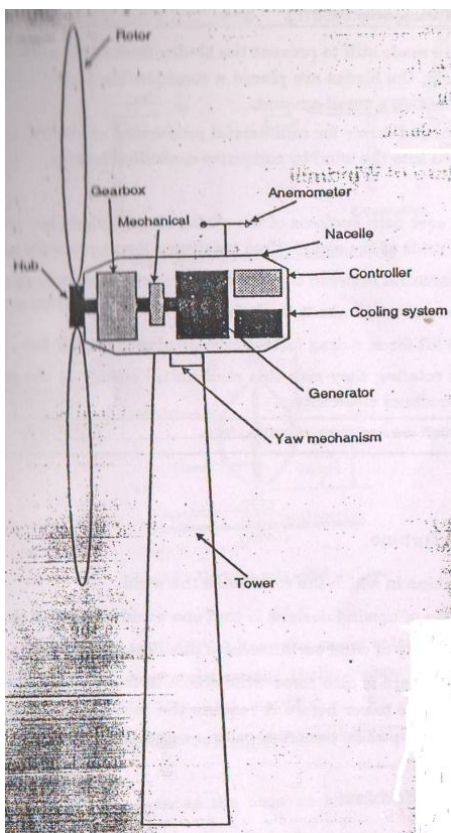
- i) **Rotor blades:** The rotor blades extract the wind energy and converts it into rotational form
- ii) **Gearbox:** It converts the rotational speed from low speed shaft and transforms it into faster rotation on the high speed shaft
- iii) **Hub:** It is the connection point for the rotor blades and low speed shaft
- iv) **Mechanical brake:** It is a disc brake used for repairs and maintenance of the wind mill.
- v) **Generator :**It converts the rotational speed of high speed shaft to electrical energy

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- vi) Yaw mechanism. This mechanism keeps the rotor blades parallel to the flow of wind
- vii) Anemometer and wind vane: They are the instruments for measuring wind speed



Basic structure of windmill

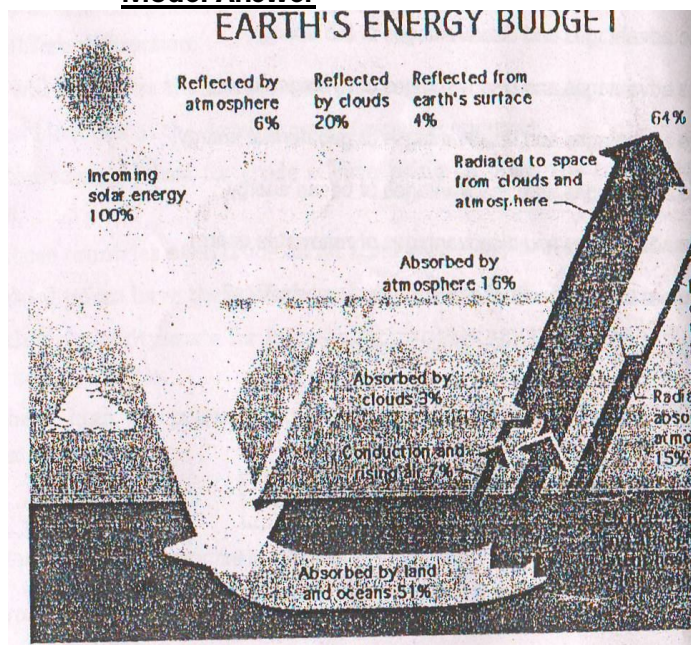
Q.No. 05 a) (02 marks for description and 02 marks for sketch)

Earth's solar energy budget: The Earth receives 174 petawatts (PW) of incoming solar radiation (insolation) at the upper atmosphere. Approx. 30% is reflected back and rest is absorbed by clouds, oceans and land masses. The absorbed solar radiation heats the land surface oceans and atmosphere. Solar radiation along with secondary resources such as wind and wave power, hydroelectricity and biomass account for 99.97% of available renewable energy on Earth. The total solar energy absorbed by Earth's atmosphere, oceans and land mass approx. 3850 zettajoules (ZJ) per year

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Q.No. 05 b) (01 marks for each difference) (Any four)

Difference between horizontal axis wind turbine & vertical axis wind turbine

Sr.no	Horizontal axis wind turbine(HAWT)	Vertical axis wind turbine(VAWT)
1.	Optimum angle of attack is available so the turbine collects the maximum amount of wind energy for the time of day & season.	Most VAWTs produce energy at only 50% of the efficiency of HAWTs in large part because of the additional drag that they have as blades rotates into the wind.
2	The tall tower base allows access to stronger wind in sides every ten meters up, the wind speed can increase by 20% & power o/p by 34%.	VAWTs do not take advantages of the stronger wind at higher elevation.
3	HAWTs have difficulty operating in near ground due to tall structure.	VAWTs can be located nearer the ground making it easier to maintain the moving parts.



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4	HAWTs require an additional yaw control mechanism to turn the blades toward the wind.	VAWTs do not need to turn to face the wind if the wind direction changes.
5	Proper foundation is required & tower is very big.	No massive tower structure is needed.
6	HAWTs need higher starting speed.	VAWTs have lower wind startup speed than HAWTs. Typically, they start creating electricity at 6m. ph. (10km/h)

Q.No. 05 c) (01 marks for each type) (Any four)

Following are the species used for biomass

- Sugarcane: Sugarcane is processed into raw sugar and molasses. Alcohol is produced by fermentation of sugarcane. .Bagasse, a residual product of sugar production is used directly as fuel.
- Canola oil: It is a edible version of rapeseed the highest yielding oil source.
- Willow: It has been main tree species for SRC- Poplar. This produces large amounts of biomass.
- Forest residues: These are produced when controlled thinning of plantations and trimming of felled trees is undertaken to reduce forest fire risk. The waste can be collected, dried and used as fuel
- Agricultural residues: It includes straw, manure, vegetables, fruit and general garden waste. It also includes potatoes and sugar beet tops as well as damaged fruit and around five million tons of nursery wastes.
- Bearing plants: Various plants have seeds that can be crushed on the farm to produce a range of vegetable oils.



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Q.No. 05 d) (04 marks for description)

Return on investment:

It is a rate of profit or sometimes just return is the ratio of money gained or lost (realized or unrealized) on an investment relative to the amount of money invested. The amount of money gained or lost may be referred to as interest, profit/loss, and gain/loss. Or net income/loss.

ROI is usually expressed as a percentage rather than decimal value. It indicates how long an investment is held.

$$\text{ROI} = (\text{Annual Net Cash flow} / \text{capital cost}) \times 100$$

It is used to compare returns on investments

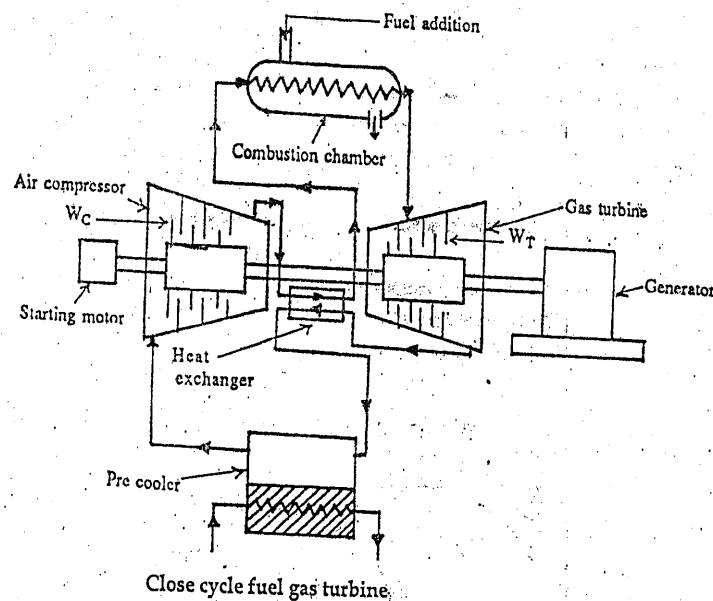
Q.No. 05 e) (02 marks for description and 02 marks for sketch)

Closed cycle gas turbine: It consists of combustor, turbine and generator. Hot combustible gases at high pressure are used to rotate turbine. The thermal energy of the gases is converted into mechanical energy and finally to electrical energy by generator. Exhaust gases coming out from the turbine are used to heat compressed air before going to combustor. Waste heat of outgoing gases is recovered using heat exchanger. Precooler is used for cooling the combustible gases before the entry to the compressor.

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CLOSED CYCLE GAS TURBINE

Q.No. 05 f) (02 marks for each)

Reuse: Reuse is using an item more than once. This includes conventional reuse where the item is used again for the same function. Reuse can have financial and environmental benefits. It has following advantages:

- i) Energy and raw materials savings.
- ii) Reduced disposal needs and costs
- iii) Refurbishment can bring sophistication
- iv) Cost saving for business and consumers
- v) Some older items were better handcrafted and appreciate in value

Recycle: It is the breaking down of the used item into raw materials which are used to make new items. . It involves processing used materials into new products in order to prevent the waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage



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, reduce air pollution and water pollution, the need for conventional waste disposal, lower greenhouse gas emissions. It is a key component of modern waste management.

Q.No. 06 a) (04 marks)

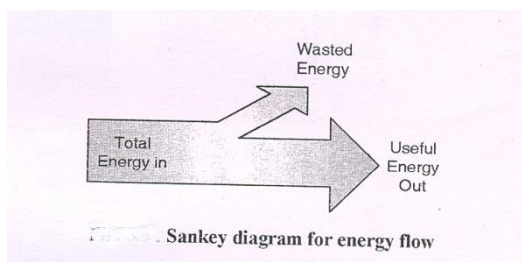
OPEC is the Organization of the Petroleum Exporting Countries. It is an oil cartel whose mission is to coordinate the policies of the oil-producing countries. The goal is to secure a steady income to the member states and a secure supply of oil to the consumers. Those who invest in petroleum activities should receive a fair return on their investments.

The founding members are Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela. Later members include Algeria, Angola, Ecuador, Gabon, Indonesia, Libya, Qatar, Nigeria, and the United Arab Emirates.

Q.No. 06 b) (02 marks for description and 02 marks for sketch)

Sankey diagrams: Sankey diagrams are a specific type of flow diagram in which the width of the arrows is shown proportionally to the flow quantity. They are typically used to visualize energy or material cost transfers between processes.

They are also commonly used to visualize the energy accounts or material flow accounts on a regional or national level. Sankey diagrams put a visual emphasis on the major transfers or flows within a system. They are helpful in locating dominant contributions to an overall flow. Often, Sankey diagrams show conserved quantities within defined system boundaries, typically energy or mass, but they can also be used to show flows of non-conserved quantities such as exergy . Sankey Diagrams drop their arrows when energy is being used.





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Q.No. 06 c) (01 mark for each) (Any four)

Objectives of energy management cell.

- 1) Conserving energy, thereby reducing cost.
- 2) Cultivating good communication on energy matters.
- 3) Developing & maintaining effective monitoring, reporting, and management strategies for efficient energy usage.
- 4) Finding new and better ways to increase return from energy investments through research & development.
- 5) Developing interest in and dedication to energy management program from all employees.

Q.No. 06 d) (02 mark for definition 02 marks for advantages) (Any four)

Thermal insulation:

The term thermal insulation can refer to materials used to reduce rate of heat transfer or the methods and processes used to reduce heat transfer.

Heat energy can be transferred by conduction, convection, radiation or when undergoing a phase change. The flow of heat can be retarded by addressing these mechanism.

Advantages of thermal insulation

- 1) Reduces over-all energy consumption
- 2) Offers better process control by maintaining process temperature.
- 3) Prevent corrosion by keeping the exposed surface of a refrigerated system above dew point.
- 4) Provides fire protection to equipment.
- 5) Absorbs vibration.

Q.No. 06 e) (04 marks)

Energy conservation in Refrigeration and air-conditioning: These systems transfer the heat energy from or the products, or building environment. Energy in the forms of electricity or heat is used. In these utilities energy saving can be done as follows:



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- i) Cold insulation: Insulate all cold lines/vessels by economic insulation thickness to minimize heat and choose appropriate insulation material
- ii) Building envelope: Optimize air conditioning volumes by measures such as use of false ceiling and segregation of critical areas for air conditioning by air curtains.
- iii) Building heat loads minimization: minimize the air-conditioning loads by measures such as roof cooling, paintings, efficient lighting, pre cooling of fresh air by heat exchangers, variable volume air system, optical thermostatic setting of temperature of spaces and sun film applications.