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 thefigure. 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 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.

Q No.	Answer	Marks	Total marks
Q1 a)	**Commercial and non commercial energy** Commercial energy is available at fixed prize in the market e.g. coal, petroleum Non commercial energy is not available at fixed price in the market but have certain value. Previously it available at home in the villages like forest dry wood, dry cow dung, human power.	1 1	2
b)	**Instruments used for energy audit:** • Electrical measuring instruments • Combustion analyzer • Thermometer (contact thermometer) • Infrared thermometer • Flow meter – Doppler effect, ultra sonic • Leak detector • Lux meter	½ mark each for any four	2
c)	**Energy conservation measures** : 1. Improved fuel storage, handling and preparation practices. 2. Insulation of steam lines and equipment. 3. Power factor improvement 4. fuel substitution, modernization of equipment and process	½ mark each	2
d)	**Non conventional energy sources** Solar thermal Solar Photovoltaic Wind energy Ocean thermal Ocean tidal	½ mark each for any four	2

	Wave energy Hydrogen energy SOFC		
e)	**NPSH** It is net positive suction head. The value which the pressure in the pump suction exceeds the liquid vapour pressure, is expressed as a head of liquid and referred to as Net positive Suction Head.	1 1	2
f)	**Bio fuels from biomass** Biodiesel Ethanol Dry Wood Biogas Briquettes from agricultural waste waste Wood gas	½ mark each for any four	2
g)	**Types of boilers** • Water tube boiler • Fire tube boiler • Packaged boilers • Stoker fired boiler • Pulverized fuel boiler • FCB boiler	½ mark each for any four	2
h)	**Power factor** The power factor of an AC electrical power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit, and is a	1	2

	dimensionless number between 0 and 1. $P = \sqrt{3} \times V \times I \times PF$	 1	
i)	**Primary energy** is an energy form found in nature that has not been subjected to any conversion or transformation process. The primary energy sources are derived from: the sun, the earth's heat, the wind, water (rivers, lakes, tides, and oceans), fossil fuels - coal, oil, and natural gas, biomass, and radioactive minerals. **Secondary energy** Secondary energy refers to the more convenient forms of energy which are transformed from other, primary, energy sources through energy conversion processes. Examples are electricity, which is transformed from primary sources such as coal, raw oil, fuel oil, natural gas, wind, sun, streaming water, nuclear power, gasoline etc.	1 1	2
j)	**Equipments used to energy from solar** Solar cooker Solar photovoltaic cell Solar furnace Solar water heater Solar dryer Solar pumps	½ mark each for any four	2
k)	**The dew point** is the temperature at which the water vapor in a sample of air at constant barometric pressure condenses into liquid water at the same rate at which it evaporates. **The dry-bulb temperature** (DBT) is the temperature of air measured by a thermometer freely exposed to the air but shielded from radiation and moisture.	1 1	2
l)	**1) Range -** is the difference between the cooling tower water inlet and outlet	1	2

	temperature. **2) Approach** - is the difference between the cooling tower outlet cold water temperature and ambient wet bulb temperature. Although, both range and approach should be monitored, the 'Approach' is a better indicator of cooling tower performance.	1	
m)	**The flash point** of a volatile fuel is the lowest temperature at which it can vaporize to form an ignitable mixture in air. **The fire point** of a fuel is the temperature at which the vapour produced by that given fuel will continue to burn for at least 5 seconds after ignition by an open flame.	1 1	2
n)	**Components of wind mill** **1) Rotor:** Blades are attached to rotor and it connected by shaft to generator. **2) Blades:** Wind lift and drag force will act on blades which are connected to rotor. **3) Shaft:** It is used to transmit mechanical power produced by blades to generator. **4) Generator:** It is device used to produce electricity using mechanical energy. **5) Tower:** It is assembly on which wind turbine is placed at certain height.	½ mark each for any four	2
2 a)	**Benchmarking** Benchmarking is the process of comparing one's business processes and performance metrics to industry bests or best practices from other companies. **Gross production related:** kWh/MT clinker or cement produced (cement plant) kWh/kg yarn produced (textile unit) kWh/MT , kcal/kg, paper produced (paper plant) kcal/kWh power produced (heat rate of power plant)	1 1.5	4

	million cal/MT urea or ammonia (fertilizer plant) kWh/MT of liquid metal output (in a foundry) **equipment related :** kW/ ton of refrigeration (on air conditioning plant) % thermal efficiency of a boiler plant % cooling tower effectiveness in a cooling tower kWh/Nm^3 of compressed air generated kWh/liter in a diesel power generation plant	1.5	
b)	**Energy security** The basic aim of energy security for a nation is to reduce its dependency on the imported energy sources for its economic growth. India will continue to experience an energy supply shortfall throughout the forecast period. Increasing dependence on oil imports means reliance on imports from the Middle East, a region susceptible to disturbances and consequent disruptions of oil supplies. Some of the strategies that can be used to meet future challenges to their energy security are • Building stockpiles • Diversification of energy supply sources • Increased capacity of fuel switching • Demand restraint • Development of renewable energy sources • Energy efficiency • Sustainable development	4	4
c)	**Direct current (DC)** is the unidirectional flow of electric charge. Direct current is produced by sources such as batteries, thermocouples, solar cells,	1 mark each	4

	and commutator-type electric machines of the dynamo type. **Alternating current (AC),** is the flow of electric charge periodically reverses direction. **An ampere** is a unit of measure of the rate of electron flow or current in an electrical conductor. One ampere of current represents one coulomb of electrical charge (6.24×10^{18} charge carriers) moving past a specific point in one second **Voltage,** also called electromotive force, is a quantitative expression of the potential difference in charge between two points in an electrical field.		
d)	**Energy saving opportunities in cooling tower** • Follow manufacturer's recommended clearances around cooling towers and relocate or modify structures that interfere with the air intake or exhaust • Optimize cooling tower fan blade angle on a seasonal and/or load basis • Correct excessive and/or uneven fan blade tip clearance and poor fan balance • In old counter-flow cooling towers, replace old spray type nozzles with new square spray nozzles that do not clog • Replace splash bars with self-extinguishing PVC cellular film fill • Install nozzles that spray in a more uniform water pattern • Clean plugged cooling tower distribution nozzles regularly • Balance flow to cooling tower hot water basins • Cover hot water basins to minimize algae growth that contributes to fouling • Optimize the blow down flow rate, taking into account the cycles of concentration (COC)	1 mark each for any four	4

<table>
<tr><td></td><td>

- limit
- Replace slat type drift eliminators with low-pressure drop, self-extinguishing PVC cellular units
- Restrict flows through large loads to design values

</td><td></td><td></td></tr>
<tr><td>e)</td><td>Power generation in India
Coal = 53.3%
Gas = 10.5 %
Oil = 0.9%
Hydro = 24.7%
Nuclear = 2.9
Reneawble = 7.7%</td><td>4</td><td>4</td></tr>
<tr><td>f)</td><td>

<table>
<tr><th>Sr No</th><th>Non conventional energy sources</th><th>Conventional energy sources</th></tr>
<tr><td>1</td><td>These sources can renew again and again.</td><td>These sources are exhaustible after use.</td></tr>
<tr><td>2</td><td>They not are available throughout year.</td><td>They are available through out year.</td></tr>
<tr><td>3</td><td>Solar, Wind, Biomass, Hydro</td><td>Coal, crude oil, Gas</td></tr>
<tr><td>4</td><td>e.g Solar cooking, Solar lamp, wind pump, solar dryer etc.</td><td>e. g Electricity from coal, FO for boiler, petrol diesel for vehicles etc.</td></tr>
</table>

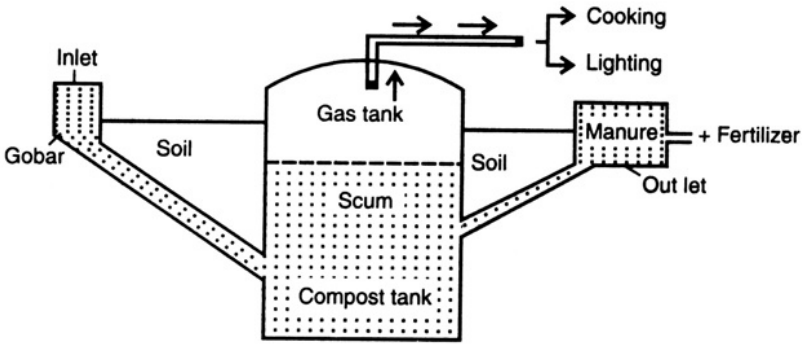
</td><td>1 mark each</td><td>4</td></tr>
<tr><td>Q3 a)</td><td>Types of biomass:
i) Traditional solid biomass: wood , agriculture waste
ii) Non-traditional biomass: which is converted in to liquid fuel
iii) Ferment the biomass: to obtain bio-gas
Cowdung</td><td>2</td><td>4</td></tr>
</table>

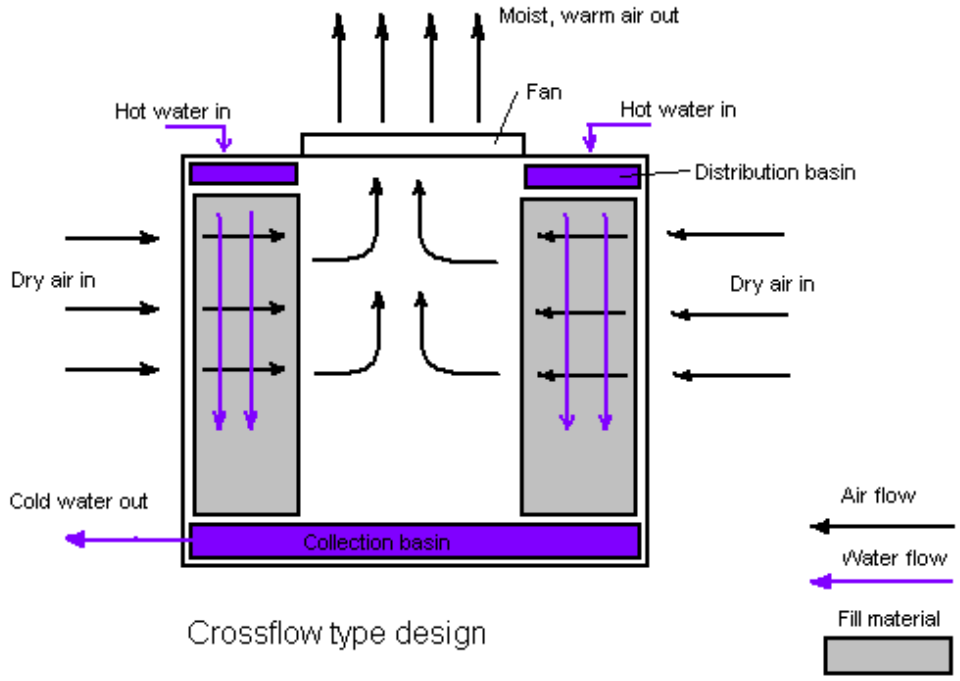
	Cornhusk Leaves Straw Garbage flesh of carcusses poultry droppings pig dung human excreta sewage etc. **Biomass used for getting energy:** The first category , is to burn the biomass directly and get the energy In the second category , the biomass is converted into ethanol and methanol to be used as a liquid fuels in engine. The third category , is to ferment the biomass anaerobically to obtain a gaseous fuel called bio-gas.	2	
b)	**Effect of speed variation:** A centrifugal pump is a dynamic device with the head generated from a rotating impeller. There is therefore a relationship between impeller peripheral velocity and generated head. Peripheral velocity is directly related to shaft rotational speed, for a fixed impeller diameter and so varying the rotational speed has a direct effect on the performance of the pump. All the parameters will be change if the speed is varied and it is important to have an appreciation of how these parameters vary in order to safely control a pump at different speeds. The equation relating rotodynamic pump performance parameters of flow , head and power absorbed , to speed are k/as the affinity laws: $Q \propto N$ $H \propto N^2$	2	4

	$P \propto N^3$ Q = FLOW RATE H = HEAD P = POWER ABSORBED N = ROTATING SPEED As can be seen from the above laws, doubling the speed of the centrifugal pump will increase the power consumption by 8 times. Conversely a small reduction in speed will result in drastic reduction in power consumption. This form the basis for energy conservation in centrifugal pumps with varying flow requirements. The most commonly used method to reduce the pump speed is variable speed drive(VSD) VSD allow pump speed adjustments overa continuous range , avoiding the need to jump from speed to speed as multiple-speed pumps. VSD control pump speed. **Impeller trimming:** Changing the impeller diameter gives the proportional change in the impeller`s peripheral velocity.simillar to the affinity laws, the following equation is apply to the impeller diameter D: $Q \propto D$ $H \propto D^2$ $P \propto D^3$ Changing the impeller diameter is an energy efficient way to control the pump flow rate This option cannot be used where varying flow pattern exist. The impeller should not be trimmed more than 25 % of the original impeller size.	2	

	Changing the impeller itself is a better option than trimming the impeller.		
c)	**Energy conservation measures in boiler** **Performance of Heat Transfer Areas**: The heat transfer areas of the boiler must be monitored. The soot blowing of the boiler must be done religiously as build up of soot acts like an insulator and reduces the heat transfer rate. That means for generating the same amount of steam more fuel will be needed. The same goes for the build-up of scale in the tubes. The stack temperature must be monitored regularly and any increase in it means that heat recovery is not optimum. If the funnel temperature increases about 40 deg C after last cleaning it indicates that boiler cleaning must be done. **Heat Loss Due to Inadequate Insulation**: The boiler and steam lines along with condensate return to the hot well must be well insulated. Over a period of time insulation is damaged or worn out. Any analysis by an infra red camera or infra red thermometer can identify the hot spots and optimize fuel consumption. **Optimum Hot Well temperature**: The hot well temperature must be maintained at temperature specified by manufacturers which is generally about 80 to 85 deg C. A lower temperature will cause colder feed water to enter the boiler thus increasing the fuel cost due to loss of sensible heat. An overheated hot well will cause vapour lock in the feed pump and loss of suction. **Steam Trap Losses**: Steam traps are used to discharge condensate once it is formed, to prevent live steam from escaping and to remove air and non condensable gases from the line.	1 mark each for any four	4

	Radiation and Convection Losses: The boiler body loses lots of heat from the exposed surfaces to the surroundings. In cold climate the loss is greater. Effective insulation can reduce these losses. **Optimize Boiler Steam pressure:** Running a boiler at lower pressure after optimizing steam usage will lower the fuel consumption. **Installation of variable speed drives**: The air dampers use throttling to obtain capacity control. **Reducing Steam Leakage**: Though this is a simply understood principle that steam leakage leads to energy and fuel loss, it is common to see many leakages of steam unattended due to either fear or apathy. Just by controlling the leakages many of the boiler operational problems can be avoided.		
d)	**Types of energy audit:** i) preliminary audit ii) detailed audit i) **preliminary energy audit:** indentify the quantity and the cost of energy forms and in the plant. Energy consumption in various equipment/sections , process level. Relates energy inputs to production and highlights the wastage of energy in equipment / process areas. Recommendation for low cost energy conservation measures. Identify of major areas/ equipments require indepth study / analysis ii**)detailed energy audit:** a comprehensive audit provides a detailed project implementation plan for a facility , since it evaluate all major energy using systems. This type of audit offers the most accurate estimate of energy savings and cost.it considers the interactive effects of all projects, accounts for the energy	4	4

	use of all major equipments , and include detailed energy cost saving calculation and project cost. Detailed audit is carried out in three phases: Phase I : pre audit phase Phase II : audit phase Phase III : post audit phase		
e)	**Biogas plant**  	4	4
f)	**Salient features of energy conservation act , 2001 :** i)Specify energy consumption standards for notified equipment and appliances ii) Direct mandatory display of label on notified equipment and appliances. iii) Prohibit manufacture , sale, purchase and import of notified equipment and appliances not conforming to energy consumption standards. iv) Notify the energy intensive industries, other establishments , and commercial buildings as designated consumers. v) Establish and prescribe the energy consumption norms and standards for designated consumers. Vi) prescribe the energy conservation buildings code for efficient use of energy etc.	1 mark each for any four	4
Q4a)	**Cross flow type of cooling tower:** Cross flow is a design in which the air flow is directed perpendicular to the	2	4

	water flow as shown in figure. Air flow enters one or more vertical faces of the cooling tower to meet the fill material. Water flows perpendicular to air through the fill by gravity. The air continuous through the fill and thus past the water flow into an open plenum area. A distribution or hot water basin consisting of a deep pan with holes or nozzles in the bottom is utilized in a cross flow tower. Gravity distributes the water through the nozzles uniformly across the fill material  Crossflow type design	2	
b)	**Wind energy:** wind turbine , like aircraft propeller blade , turn in the moving air and power an electric generator , that supplies an electric current. Simply stated , a wind turbine is the opposite of a fan. Instead of using electricity to make wind, like a fan , wind turbines use wind to make electricity. The wind turns the blades,	4	4

which spin a shaft, which connects to a generator and make electricity.

Wind turbine types:

Horizontal- axis

Vertical – axis design.

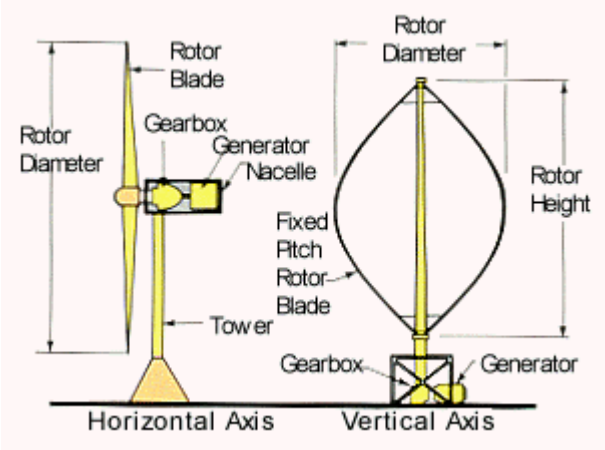
Horizontal turbine components include:

blade or rotor :which convert the energy in the wind to rotational shaft energy

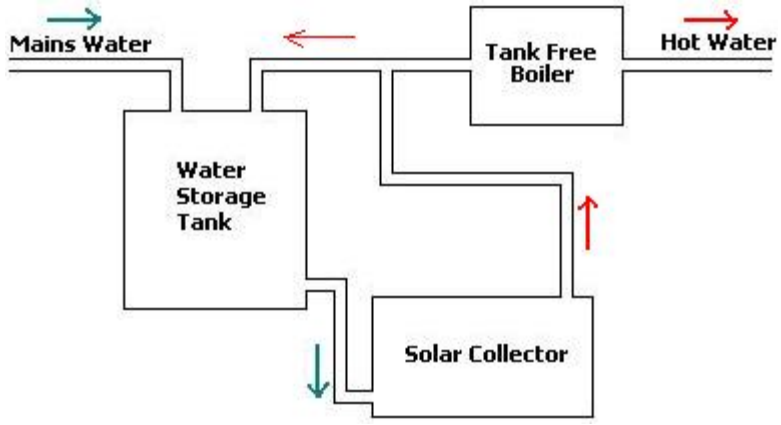
A drive train: usually including a gearbox and a generator

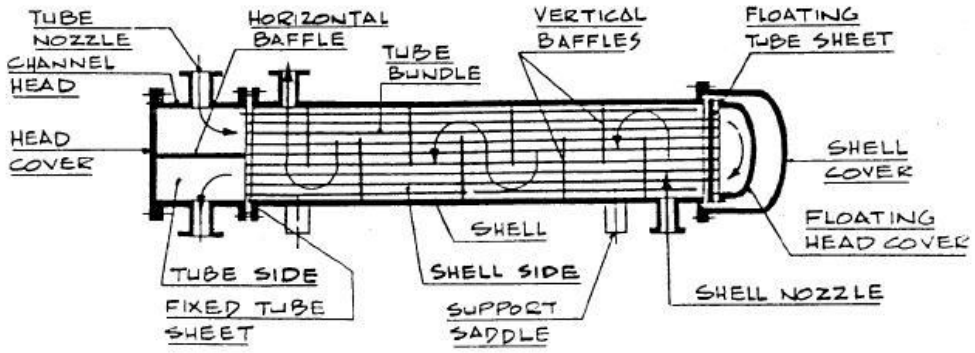
A tower : that supports the rotor and drive train

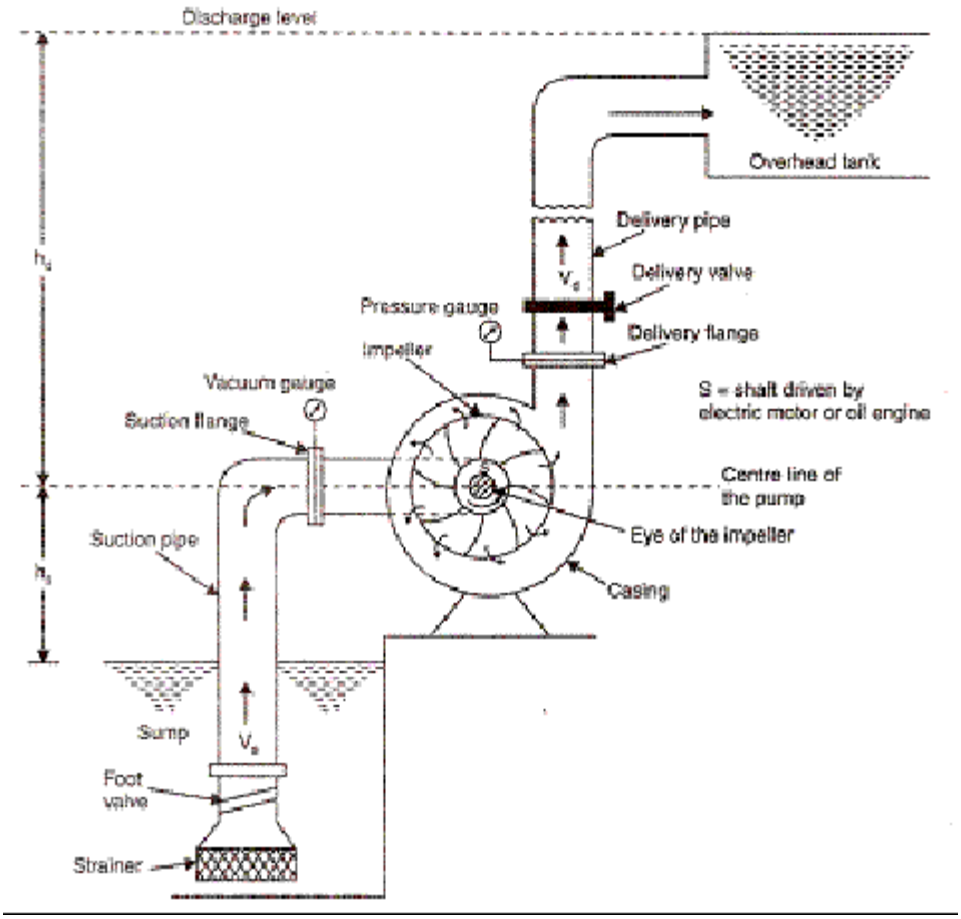
Other equipments: including controls , electrical cables , ground supports equipments and interconnection equipments.



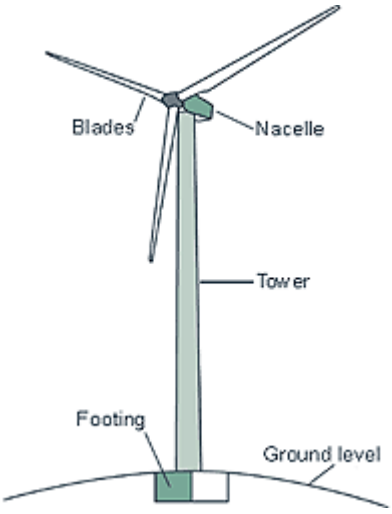
c)	**Latent heat:** It is the heat that does not affect the temperature but change the state of substance when added to or abstracted from it. **Specific heat:** The specific heat is the amount of heat per unit mass required to raise the temperature by one degree Celsius. **Humidity:** a quantity representing the amount of water vapour in the atmosphere or in a gas.	1.5 1.5 1	4
d)	**Solar water heater:** Solar water heating (SWH) is the conversion of sunlight into renewable energy for water heating using a solar thermal collector. Solar water heating systems comprise various technologies that are used worldwide increasingly. In a "close-coupled" SWH system the storage tank is horizontally mounted immediately above the solar collectors on the roof. No pumping is required as the hot water naturally rises into the tank through thermo siphon flow. In a "pump-circulated" system the storage tank is ground- or floor-mounted and is below the level of the collectors; a circulating pump moves water or heat transfer fluid between the tank and the collectors. SWH systems are designed to deliver hot water for most of the year. However, in winter there sometimes may not be sufficient solar heat gain to deliver sufficient hot water.	2	4

		2	
e)	Energy consumption = V x I x cos θ x number of hours per day = 230 x 2 x 0.85 x 12 = 4692 watt hours or 4.692 kWh per day	4	4
f)	**Contents of energy audit report** Introduction General requirements Engineering calculation methods Scope of report Energy Audit Report outline Key contacts information Table of contents Executive summary Introduction Energy consumption Baseline period enrgy consumption System, process or equipment description Energy efficiency upgrades Economic analysis	4	4

	Conclusions and recommendations Appendix		
Q 5 a)	**Shell and tube heat exchanger** 	4	4
b)	**A leak detector** is a device that detects the presence of gases in an area, often as part of a safety system. This type of equipment is used to detect a gas leak and interface with a control system so a process can be automatically shut down. A gas detector can sound an alarm to operators in the area where the leak is occurring, giving them the opportunity to leave. This type of device is important because there are many gases that can be harmful to organic life, such as humans or animals. Gas detectors can be used to detect combustible, flammable and toxic gases, and oxygen depletion. This type of device is used widely in industry and can be found in locations, such as on oil rigs, to monitor manufacture processes and emerging technologies such asphotovoltaic. They may be used in firefighting. **A lux meter** is a device for measuring brightness, specifically, the intensity with which the brightness appears to the human eye. This is different than	2 2	4

	measurements of the actual light energy produced by or reflected from an object or light source. The lux is a unit of measurement of brightness, or more accurately.		
c)	**Centrifugal pump** 	4	4
d)	**The Perform Achieve Trade (PAT)** is an innovative, market-based trading scheme announced by the Indian Government in 2008 under its National Mission on Enhanced Energy Efficiency (NMEEE) in National Action Plan on Climate Change (NAPCC). It aims to improve energy efficiency in industries by trading in energy efficiency certificates in energy-intensive sectors.The 2010 amendment to the Energy Conservation Act (ECA) provides a legal	4	4

	mandate to PAT. Participation in the scheme is mandatory for Designated Consumers under the ECA. It is being administered by the BEE that sets mandatory, specific targets for energy consumption for larger, energy-intensive facilities. The PAT Scheme is being implemented in three phases- the first phase runs from 2012-2015 covering 478 facilities from eight energy-intensive sectors, namely aluminium, cement, chlor-alkali, fertilizer, iron and steel, pulp and paper, textiles and thermal power plants. This accounts for roughly 60% of India's total primary energy consumption. It targets energy consumption reductions of 6.6 million tons of oil equivalent in the 478 covered facilities. The scheme imposes mandatory specific energy consumption targets on the covered facilities with less energy efficient facilities having a greater reduction target than the more energy efficient ones.. A facility's baseline is determined by its historic specific energy consumption between 2007-2010. Facilities making greater reductions than their targets receive "EsCerts" or "energy saving certificates" which can be traded with facilities that are having trouble meeting their targets, or banked for future use. The PAT scheme establishes plant-specific targets rather than a sectoral target, with the average reduction target being 4.8% that is to be achieved by the end of the first phase (2015).		
e)	**Components of wind turbine** **1) Rotor:** Blades are attached to rotor and it connected by shaft to generator. **2) Blades:** Wind lift and drag force will act on blades which are connected to rotor. **3) Shaft:** It is used to transmit mechanical power produced by blades to generator. **4) Generator:** It is device used to produce electricity using mechanical energy.	3	4

	5) Tower: It is assembly on which wind turbine is placed at certain height. **Working** • Tower produces turbulence behind it, the turbine is usually pointed upwind of the tower. • The wind passes over both surfaces of the airfoil shaped blade but passes more rapidly over the longer (upper) side of the airfoil, thus creating a lower-pressure area above the airfoil. • The pressure differential between top and bottom surfaces results in aerodynamic lift. • The lift force causes rotation about the hub. • In addition to the lift force, a drag force perpendicular to the lift force impedes rotor rotation. • When blades are rotating they give this mechanical energy to the generator shaft through gear box, which produces electricity.  	1	
f)	**Medium term and long term measures of energy conservation**	2	4

	Medium-term strategy: • Demand management through greater conservation of energy, optimum fuel mix, structural changes in the economy, an appropriate model mix in the transport sector, i.e. greater dependence on rail than on road for the movement of goods and passengers and a shift away from private modes to public modes for passenger transport; changes in design of different products to reduce the material intensity of those products, recycling, etc. • There is need to shift to less energy-intensive modes of transport. This would include measures to improve the transport infrastructure viz. roads, better design of vehicles, use of compressed natural gas (CNG) and synthetic fuel, etc. Similarly, better urban planning would also reduce the demand for energy use in the transport sector. • There is need to move away from non-renewable to renewable energy sources viz. solar, wind, biomass energy, etc. **Long-term strategy:** Efficient generation of energy resources • Improving energy efficiency in accordance with national, socio-economic, and environmental priorities • Promoting of energy efficiency and emission standards • Creation of urban gas transmission and distribution network • Maximizing efficiency of rail transport of coal production. • Building new coal and gas fired power stations. Enhancing energy efficiency • Labeling programmes for products and adoption of energy efficient	2	

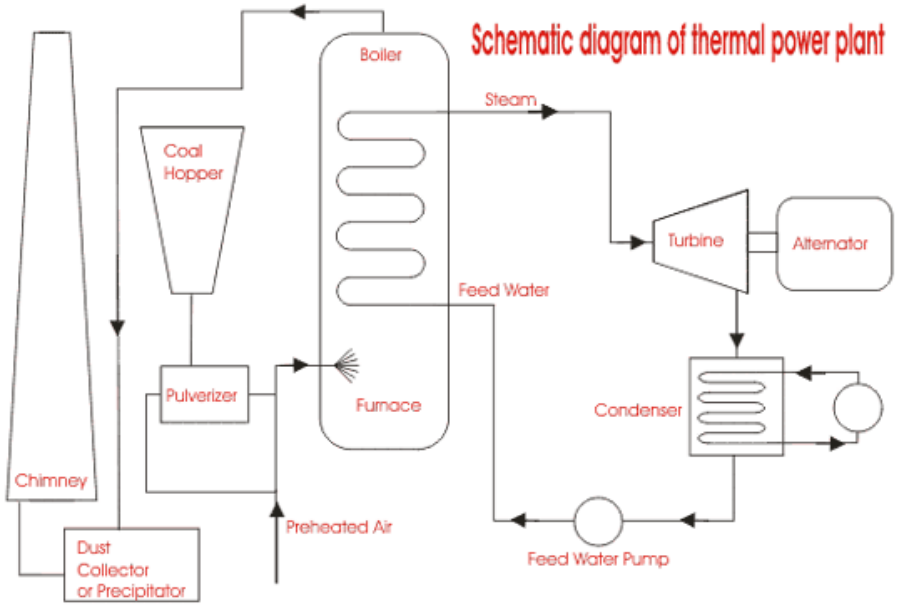
	technologies in large industries Deregulation and privatization of energy sector • Reducing cross subsidies on oil products and electricity tariffs • Decontrolling coal prices and making natural gas prices competitive • Privatization of oil, coal and power sectors for improved efficiency. Investment legislation to attract foreign investments. • Streamlining approval process for attracting private sector participation in power generation, transmission and distribution.		
6 a)	**Energy saving opportunities in cooling tower** • Follow manufacturer's recommended clearances around cooling towers and relocate or modify structures that interfere with the air intake or exhaust • Optimize cooling tower fan blade angle on a seasonal and/or load basis • Correct excessive and/or uneven fan blade tip clearance and poor fan balance • In old counter-flow cooling towers, replace old spray type nozzles with new square spray nozzles that do not clog • Replace splash bars with self-extinguishing PVC cellular film fill • Install nozzles that spray in a more uniform water pattern • Clean plugged cooling tower distribution nozzles regularly • Balance flow to cooling tower hot water basins • Cover hot water basins to minimize algae growth that contributes to fouling • Optimize the blow down flow rate, taking into account the cycles of concentration (COC) • limit	1 mark each for any four	4

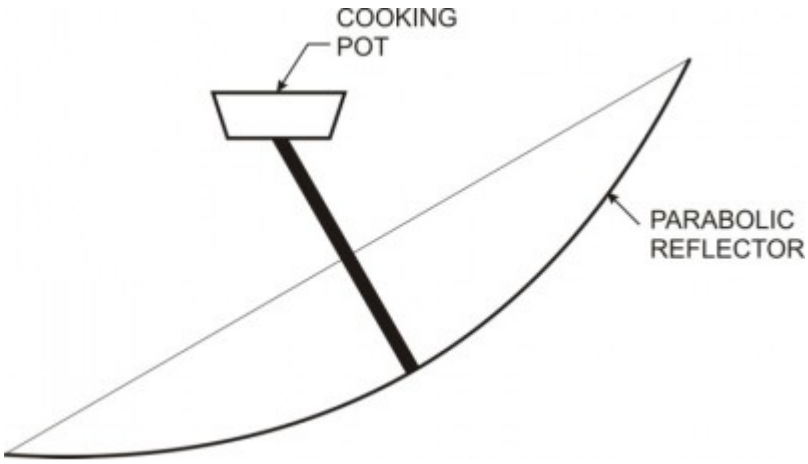
	• Replace slat type drift eliminators with low-pressure drop, self-extinguishing PVC cellular units • Restrict flows through large loads to design values		
b)	**Wave and tidal energy** In addition to its abundant solar, wind and geothermal resources, we can capture the renewable energy of the ocean. Special buoys, turbines, and other technologies can capture the power of waves and tides and convert it into clean, pollution-free electricity. Like other renewable resources, both wave and tidal energy are variable in nature. Waves are produced by winds blowing across the surface of the ocean. However, because waves travel across the ocean, their arrival time at the wave power facility may be more predictable than wind. In contrast, tidal energy, which is driven by the gravitational pull of the moon and sun, is predictable centuries in advance. **Geothermal energy** Geothermal power plants use steam produced from reservoirs of hot water found a few miles or more below the Earth's surface to produce electricity. The steam rotates a turbine that activates a generator, which produces electricity. There are three types of geothermal power plants: dry steam, flash steam, and binary cycle. Geothermal power is cost effective, reliable, sustainable, and environmentally friendly, Geothermal wells release greenhouse gases trapped deep within the earth, but these emissions are much lower per energy unit than those of fossil fuels. As a result, geothermal power has the potential to help mitigate global warming if widely deployed in place of fossil fuels.	2 2	4
c)	**Energy Performance Assessment of Heat Exchangers** Heat exchangers are equipment that transfer heat from one medium to another.	4	4

	The proper design, operation and maintenance of heat exchangers will make the process energy efficient and minimize energy losses. Heat exchanger performance can deteriorate with time, off design operations and other interferences such as fouling, scaling etc. It is necessary to assess periodically the heat exchanger performance in order to maintain them at a high efficiency level. We have To determine the overall heat transfer coefficient for assessing the performance of the heat exchanger. Any deviation from the design heat transfer coefficient will indicate occurrence of fouling. This is a fairly rigorous method of monitoring the heat exchanger performance by calculating the overall heat transfer coefficient periodically. Technical records are to be maintained for all the exchangers, so that problems associated with reduced efficiency and heat transfer can be identified easily. The record should basically contain historical heat transfer coefficient data versus time / date of observation. A plot of heat transfer coefficient versus time permits rational planning of an exchanger-cleaning program. Heat Duty: Actual duty differences will be practically negligible as these duty differences could be because of the specific heat capacity deviation with the temperature. Also, there could be some heat loss due to radiation from the hot shell side. Pressure drop: Also, the pressure drop in the shell side of the hot fluid is reported normal (only slightly less than the design figure). This is attributed with the increased average bulk temperature of the hot side due to decreased performance of the exchanger. Temperature range: As seen from the data the deviation in the temperature ranges could be due to the increased fouling in the tubes (cold stream), since a higher pressure drop is noticed.		

	Heat Transfer coefficient: The estimated value has decreased due to increased fouling that has resulted in minimized active area of heat transfer. Physical properties: If available from the data or Lab analysis can be used for verification with the design data sheet as a cross check towards design considerations. Troubleshooting: Fouled exchanger needs cleaning.		
d)	**Modes of heat transfer** 1. Conduction 2. Convection and 3. Radiation CONDUCTION: Conduction is the mode of heat transfer occurs from one part of a substance to another part of within the substance itself or with another substance which is placed in physical contact. In conduction, there is no noticeable movement oof molecules. You ight be think that then how this heat tranbsfer occurs? The heat transfer occurs here by the two mechanisms happen. 1. By the transfer of free electrons. (Good conductors like metals have a plenty of free electrons to make conductive heat transfer. 2. The atoms and molecules having energy will pass those energy they have with their adjacent atoms or molecules by means of lattice vibrations. CONVECTION: Conductive heat transfer occurs within a fluid itself and it is carried out by transfer of one fraction of the fluid to the remaining portion. Hence unlike conduction, transfer of molecules occurs during convection. Since movement of particles constitutes convection, it is the macro form of heat transfer. Also	4	4

	convection is onlyh [possible in fluids where the particles can moved easily and thye rate of convective heat transfer depends on the rate of flow to a great extend. Convection can be of two types: 1. Natural convection: In this type of convection, the movement of particles which constitutes convection occurs by the variation in densities of the fluids. As we already know, as temperature increases, the density decreases and this variation in density will force the fluid to move through the volume. This cause convection to occur. 2. Forced Convection: The difference between natural convection and forced convection is that in forced convection, a work is done to make movement in the fluid. This is done using a pump or blower. RADIATION Radiation is the third mode of heat transfer. This mode of heat transfer didn't require any medium to occur. Every matter having a temperature above absolute zero will emit energy in the form of electromagnetic waves and called radiation. It is the same way the energy of the Sun reach us. The key features about radiation are it do not require any medium and also laws of reflection is applicable for radiation.		
e)	**Thermal power plant** The theory of thermal power station or working of thermal power station is very simple. A power generation plant mainly consists of alternator runs with help of steam turbine. The steam is obtained from high pressure boilers. Generally in India, bituminous coal, brown coal and peat are used as fuel of boiler. The bituminous coal is used as boiler fuel has volatile matter from 8 to 33 % and ash content 5 to 16 %. To increase the thermal efficiency, the coal is used in the boiler in powder form. In coal thermal power plant, the steam is produced in high pressure in the	2	4

	steam boiler due to burning of fuel (pulverized coal) in boiler furnaces. This steam is further supper heated in a super heater. This supper heated steam then enters into the turbine and rotates the turbine blades. The turbine is mechanically so coupled with alternator that its rotor will rotate with the rotation of turbine blades. After entering in turbine the steam pressure suddenly falls and corresponding volume of the steam increases. After imparting energy to the turbine rotor the steam passes out of the turbine blades into the condenser. In the condenser the cold water is circulated with the help of pump which condenses the low pressure wet steam. This condensed water is further supplied to low pressure water heater where the low pressure steam increases the temperature of this feed water, it is again heated in high pressure.  	2	
f)	**Parabolic solar cooker** Parabolic solar cookers concentrate sunlight to a single point. When this point is focused on the bottom of a pot, it can heat the pot quickly to very high temperatures which can often be comparable with the temperatures achieved in	2	4

	gas and charcoal grills. These types of solar cookers are widely used in several regions of the world, most notably in China and India where hundreds of thousands of families currently use parabolic solar cookers for preparing food and heating water. Some parabolic solar cooker projects in China abate between 1-4 tons of carbon dioxide per year and receive carbon credits through the Clean Development Mechanism (CDM) and Gold Standard. Some parabolic solar cookers incorporate cutting edge materials and designs which lead to solar energy efficiencies >90% (such as theSolSource developed by One Earth Designs). Others are large enough to feed thousands of people each day, such as the solar bowl at Auroville in India, which makes 2 meals per day for 1,000 people. If a reflector is axially symmetrical and shaped so its cross-section is a parabola, it has the property of bringing parallel rays of light (such as sunlight) to a point *focus*. If the axis of symmetry is aimed at the sun, any object that is located at the focus receives highly concentrated sunlight, and therefore becomes very hot. This is the basis for the use of this kind of reflector for solar cooking.  	2	