Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in themodel answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may tryto assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given moreImportance (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 constantvalues may vary and there may be some difference in the candidate's answers and modelanswer.
6) In case of some questions credit may be given by judgement on part of examiner of relevantanswer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based onequivalent concept.

Q No.	Answer	Marks
1 A	**Attempt any three**	**12**
a)	**Energy conservation act 2001** The Act empowers the Central Government and, in some instances, State Governments to: • specify energy consumption standards for notified equipment and appliances; direct mandatory display of label on notified equipment and appliances; • prohibit manufacture, sale, purchase and import of notified equipment and appliances not conforming to energy consumption standards; • notify energy intensive industries, other establishments, and commercial buildings as designated consumers; • establish and prescribe energy consumption norms and standards for designated consumers; • prescribe energy conservation building codes for efficient use of energy and its conservation in new commercial buildings having a connected load of 500 kW or a contract demand of 600 kVA and above; **direct designated consumers to -** • designate or appoint certified energy manager in charge of activities for efficient use of energy and its conservation; • get an energy audit conducted by an accredited energy auditor in the specified manner and interval of time; • furnish information with regard to energy consumed and action taken on the recommendation of the accredited energy auditor to the designed	One mark each for any four

	agency; • comply with energy consumption norms and standards; • prepare and implement schemes for efficient use of energy and its conservation if the prescribed energy consumption norms and standards are not fulfilled; • get energy audit of the building conducted by an accredited energy auditor in this specified manner and intervals of time;	
b)	**Biogas** **Construction** It consits of inlet tank, digester and outlet tank. Sluury is prepeared in inlet tank. Mass is digeated in digester. Gas is collected at the top dome. Digested mass comes our from outlet tank. Gas is taken out by outlet pipe from top. **Working** • The feed material is mixed with water in the influent collecting tank The fermentation slurry flows through the inlet into the digester. • The bacteria from the fermentation slurry are intended to produce biogas in the digester. • 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, alcohol, carbon dioxide, hydrogen, ammonia and sulfides. • This stage is called “hydrolysis” (or “liquefaction”). • Next, acetogenic (acid-forming) bacteria further digest the products of hydrolysis into acetic acid, hydrogen and carbon dioxide. • Methanogenic (methane-forming) bacteria then convert these	2+2

	products into biogas. • The combustion of digester gas can supply useful energy in the form of hot air, hot water or steam.	
c)	**The need of energy audit-** In any industry, the three top operating expenses are often found to be energy (both electricaland thermal), labour and materials. If one were to relate to the manageability of the cost orpotential cost savings in each of the above components, energy would invariably emerge as atop ranker, and thus energy management function constitutes a strategic area for cost reduction.Energy Audit will help to understand more about the ways energy and fuel are used in anyindustry, and help in identifying the areas where waste can occur and where scope for improvementexists. The Energy Audit would give a positive orientation to the energy cost reduction, preventivemaintenance and quality control programmes which are vital for production and utility activities.Such an audit programme will help to keep focus on variations which occur in the energycosts, availability and reliability of supply of energy, decide on appropriate energy mix, identifyenergy conservation technologies, retrofit for energy conservation equipment etc. In general, Energy Audit is the translation of conservation ideas into realities, by lendingtechnically feasible solutions with economic and other organizational considerations within aspecified time frame. The primary objective of Energy Audit is to determine ways to reduce energy consumptionper unit of product output or to lower operating costs. Energy Audit provides a “bench-mark"(Reference point) for managing energy in the organization and also provides the basis for planninga more effective use of	4

	energy throughout the organization.	
d)	**Energy generated from tide and wave** ***Tidal*** The technology required to convert tidal energy into electricity is comparable to technology used in traditional hydroelectric power plant. The first requirement is a dam across the tidal bay.Best sites are those where a bay has narrow openings, thus reducing the length of dam required.Gates and turbines are installed. When there is an adequate difference in the level of the water on the different sides of the dam, the gates are opened.This causes water to flow though the turbines, turning the generator to produce electricity.Electricity produced by water flowing both inwards and out of a bay. There are periods of maximum generation every 12 hrs. , with no electricity generation at the 6 hrs. mark in between. The turbines may also used pumps to pump extra water into the basin behind the dam at times when demand on electricity is low.This water can later be released when the demand on the system is very high. ***Wave*** Waves are generated by wind passing over the surface of the sea. As long as the waves propagate slower than the wind speed just above the waves, there is an energy transfer from the wind to the waves. Both air pressure differences between the upwind and the lee side of a wave crest, as well as friction on the water surface by the wind, making the water to go into the shear stress causes the growth of the waves. Wave power is the transport of energy by wind waves, and the capture of that energy to do useful work – for example, electricity generation, water desalination, or the pumping of water (into reservoirs). A machine able to exploit wave power is generally known as a wave energy converter (WEC).	2 2

1B	Attempt any one	6
a)	**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 dimensionless number between 0 and 1. It is calculated by following formula P = √3 x V x I x PF Given : active power P = 1.6 kW V = 440 V , I = 2.6 Amp. Apparent power =[√3 x V x I] / 1000 =[√3 x 440 x 2.6] / 1000 = 1.98 Power factor = active power / apparent power = 1.6/ 1.98 = 0.8080	1 1 4
b)	**Types of fuels** Solid fuels: Coal, Uranium, Wood Liquid fuel : Petroleum products (petrol, diesel, aviation fuel),biodiesel, ethanol Gaseous fuel : LPG, CNG, Biogas, Hydrogen **Gross Calorific Value** The gross heating value is obtained whenall products of the combustion are	2 2

	cooled down to the temperature before the combustion considering the water vapor formed during combustion is condensed. **Net Calorific Value** The net or lower heating value is obtained bysubtracting the latent heat of vaporization of the water vapor formed by the combustion from the gross or higher heating value.	2
2	**Attempt any four**	**16**
a)	**Instruments used for energy audit:** • Electrical measuring instruments- to measure current, voltage, power, PF • Combustion analyzer- For flue gas analysis • Thermometer (contact thermometer)- For temperature measurement • Infrared thermometer- For temperature measurement • Flow meter – Doppler effect, ultra sonic – for flow measurement • Leak detector- To find change in pressure • Lux meter – to measure intensity of light These parameters are required for material and energy balance during audit.	3 1
b)	**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	2 2

	from primary sources such as coal, raw oil, fuel oil, natural gas, wind, sun, streaming water, nuclear power, gasoline etc. **OR** **Conventional Energy sources:** These sources are exhaustible after use. e.g Coal, crude oil, Gas **Non-Conventional energy sources:** These sources can renew again and again. e.g Solar, Wind, Biomass, Hydro	
c)	**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 dimensionless number between 0 and 1. Power Factor (PF) is the ratio between the active power (kW) and apparent power (kVA). $$\text{Power Factor }(\cos\Phi) = \frac{Active\ Power\ (kW)}{Apparent\ Power\ (kVA)} = \frac{kW}{\sqrt{(kW)^2 + (kVAr)^2}}$$	2

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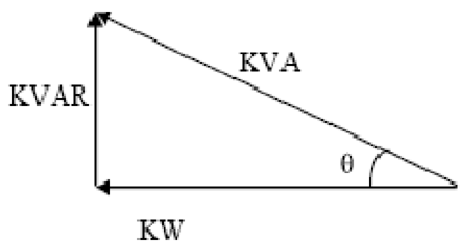
The Power Triangle



$$P.F. = \frac{KW}{KVA} = \cos\theta$$

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<tr><td>d)</td><td>

Types of heat exchangers based on construction

Shell-and-Tube Exchangers

This exchanger is generally built of a bundle of round tubes mounted in a cylindrical shell with the tube axis parallel to that of the shell. One fluid flows inside the tubes, the other flows across and along the tubes. The major components of this exchanger are tubes (or tube bundle), shell, front-end head, rear-end head, baffles, and tube sheets.

Double-Pipe Heat Exchangers

This exchanger usually consists of two con- centric pipes with the inner pipe plain or finned. One fluid flows in the inner pipe and the other fluid flows in the annulus between pipes in a counter flow direction for the ideal highest performance for the given surface area. However, if the application requires an almost constant wall temperature, the fluids may flow in a parallelflow direction.

Spiral Tube Heat Exchangers

These consist of one or more spirally wound coils fitted in a shell. Heat transfer rate associated with a spiral tube is higher than thatfor a straight tube.

</td><td>1 mark each for any four</td></tr>
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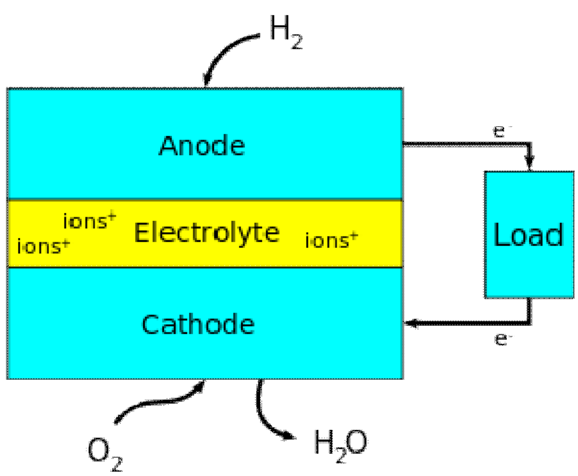
	In addition, a considerable amount of surface can be accommodated in a given space by spiraling. Thermal expansion is no problem, but cleaning is almost impossible. *Plate-Type Heat Exchangers* Plate-type heat exchangers are usually built of thin plates (all prime surface). The plates are either smooth or have some form of corrugation, and they are either flat or wound in an exchanger. Generally, these exchangers cannot accommodate very high pressures. *Plate-Fin Heat Exchangers* This type of exchanger has corrugated fins (most commonly having triangular and rectangular cross sections) or spacers sandwiched between parallel plates (referred to as plates or parting sheets). Sometimes fins are incorporated in a flat tube with rounded corners (referred to as a formed tube), thus eliminating the need for side bars. *Tube-Fin Heat Exchangers* These exchangers may be classified as conventional and specialized tube-fin exchangers. In a conventional tube-fin exchanger, heat transfer between the two fluids takes place by conduction through the tube wall. However, in a heat pipe exchanger (a specialized type of tube-fin exchanger), tubes with both ends closed act as a separating wall, and heat transfer between the two fluids takes place through this ‘‘separating wall’’ (heat pipe) by conduction, and evaporation and condensation of the heat pipe fluid. Let us first describe conventional tube-fin exchangers and then heat pipe exchangers.	
e)	**Energy conservation** Energy Conservation is the deliberate practice or an attempt to save electricity, fuel oil or gas or any other combustible material, to be able to put to additional	2

	use for additional productivity without spending any additional resources or money. Energy is a scarce commodity; Energy in any form is a scarce commodity and an expensive resource. During the last four decades the induction of energy efficient technologies has lead to dramatic reduction in energy usage in chemical process industries. Due to compulsions from global competition to be highly cost competitive and the awareness thereof, companies are on a drive to reduce costs. Energy consumption in Chemical Process Industries (CPI) is dependent on the products manufactured and process employed. Energy cost in caustic chlorine plant is around 60% of the manufacturing cost. **Importance** a) To reduce imports of energy and reduce the drain on foreign exchange. b) To improve exports of manufactured goods (either lower process or increased availability helping sales) or of energy, or both. c) To reduce environmental pollution per unit of industrial output - as carbon dioxide, smoke, sulphurdioxide, dust, grit or as coal mine discard for example. d) Thus reducing the costs that pollution incurs either directly as damage, or as needing, special measures to combat it once pollutants are produced. e) Generally to relieve shortage and improve development.	2
3	**Attempt any four**	**16**
a)	**Fuel cell** Fuel cells come in many varieties; however, they all work in the same general manner. They are made up of three adjacent segments: the anode, the electrolyte, and the cathode. Two chemical reactions occur at the interfaces of the three different segments. The net result of the two reactions is that fuel is consumed, water or carbon dioxide is created, and an electric current is	**4**

	created, which can be used to power electrical devices, normally referred to as the load. At the anode a catalyst oxidizes the fuel, usually hydrogen, turning the fuel into a positively charged ion and a negatively charged electron. The electrolyte is a substance specifically designed so ions can pass through it, but the electrons cannot. The freed electrons travel through a wire creating the electric current. The ions travel through the electrolyte to the cathode. Once reaching the cathode, the ions are reunited with the electrons and the two react with a third chemical, usually oxygen, to create water or carbon dioxide.  	
b)	**Advantages of direct method:** • Plant people can evaluate quickly the efficiency of boilers • Requires few parameters for computation • Needs few instruments for monitoring **Disadvantages of direct method:** • Does not give clues to the operator as to why efficiency of system is lower	2 2

	• Does not calculate various losses accountable for various efficiency levels	
c)	**An energy audit consists following steps** Data collection: the auditor starts collecting some preliminary information on the energy consumption of the facilities and some technical details such as process diagrams, drawings and equipment inventory - usually provided by the organization. Field work: at least one on-site visit is required, with the aim of gathering all the information needed for the study depending on the defined scope. This information includes collecting details of the energy consuming equipment such as brand, model, power and hours of operation. Some interviews with staff will also be required. Depending on the type of energy audit, some metering devices will be used. Analysis of energy consumption and performance of energy accounting: all the operations of the organization must be analyzed, as well as the equipment consuming higher energy. The processes which have higher energy consumption must be identified in order to determine the potential for reducing it and to define the energy saving measures to improve global energy performance. All information collected is used to evaluate the different uses of energy within the process and to establish a breakdown of the energy consumed. This energy accounting is also called Energy Balance.	4

	Analysis and development of energy saving measures: once all the data collected has been analyzed, energy saving measures can be identified. The information collected and analyzed enables the auditor to detect energy saving measures to reduce energy consumption. Energy and cost savings of these measures will be assessed, together with investment needed and payback. Energy audit report: following the energy audit, an energy audit report must be issued, which should include at least the following information: Technical scope: this point includes facilities, services and included areas and level of depth in the analysis and detail required. Methodology: this point includes the analysis of the state of art of the facilities (energy inputs, technologies and services), measurement results and energy balance. Suggested energy saving measures: this point includes a description of each energy saving measure, including potential energy savings, economic savings, investment needed and payback. Conclusions: this point includes the recommended measures, total energy savings, total economic savings, total investment and payback.	
d)	**Power available in wind** The kinetic energy (**KE**) of an object (or collection of objects) with total mass **M** and velocity **V** is given by the expression: $KE = 1/2 M V^2$ Now, for purposes of finding the kinetic energy of moving air molecules (i.e.:wind), let's say one has a large air parcel with the shape of a huge hockey	4

puck: that is, it has the geometry of a collection of air molecules passing though the plane of a wind turbine's blades (which sweep out a cross-sectional area **A**), with thickness (**D**) passing through the plane over a given time. The volume (**Vol**) of this parcel is determined by the parcel's area multiplied by its thickness:

$$Vol = A\ D$$

Let ρ(the greek letter 'rho') represent the density of the air in this parcel. Note that density is mass per volume and is expressed as:

$$\rho = M / Vol$$

and a little algebra gives: $M = \rho Vol$

Now let's consider how the velocity (**V**) of our air parcel can be expressed. If a time **T** is required for this parcel (of thickness **D**) to move through the plane of the wind turbine blades, then the parcel's velocity can be expressed as

$$V = D / T,$$

and a little algebra gives

$$D = V\ T$$

Let's make some substitutions in expression no. 1 **(KE = 1 / 2 M V^2)**

Substitute for **M (=ρVol)** to obtain:

$$KE = 1/2\ (\rho Vol)\ V^2$$

And **Vol**can be replaced by **A D** to give:

$$KE = 1/2\ (\rho\ A\ D)\ V^2$$

And **D** can be replaced by **V * T** to give**:**

$$KE = 1/2\ (\rho\ A\ V\ T)\ V^2$$

Leaving us with:

	$KE = 1/2\,\rho\,V^3\,A\,T$ Now, power is just energy divided by time, so the power available from our air parcel can be expressed as : $P = KE / T$ $= (1/2\,\rho\,V^3\,A\,T) / T$ $P = 1/2\,\rho\,V^3\,A$	
e)	**Features of Perform Achieve Trade (PAT)** • Specification of specific energy consumption (SEC) norm for each designated consumer in the baseline year and in the target year • Verification of the SEC of each designated consumer in the baseline year and in the target year by an accredited verification agency • Issuance of Energy Savings Certificates (ESCerts) to those designated consumers who exceed their target SEC reduction • Trading of ESCerts with designated consumers who are unable to meet their target SEC reduction after three years • Checking of compliance, and reconciliation of ESCerts at the end of the 3-year period. In case of non-compliance, a financial penalty is due.	1 mark for each for any four
4 A	**Attempt any three**	**12**
a)	**Centrifugal Pump** **Construction** Pumps are the mechanical devices that convert mechanical energy into hydraulic energy. They are generally used to raise the water or other fluids from lower elevation to higher elevation. So pumps are generally classified into centrifugal pump and positive displacement pump. Centrifugal pumps are non- positive displacement pumps. They work on the principle of centrifugal	2

action.

Centrifugal pump works on the principle that a fluid of mass is given a force it is thrown outward radially. The main parts of the centrifugal pump include

- Suction eye
- Vanes
- Impeller
- Casing
- Suction pipe
- Discharge pipe

The suction pipe is connected to the sump or a ground level tank from where the fluid has to be pumped. The suction pipe at the sump is connected with strainer thus restricting any foreign particles entering into the pump. Generally as the length of the suction pipe is less the friction loss also will be less.

The other end of the suction pipe is connected to the suction eye of the pump. The suction eye is the first point of entry of water into pump. The discharge pipe is connected to the above level where the fluid has to be delivered.

Since the length of the discharge pipe is long the friction loss will also be higher at the discharge end.

The casing of the pump is designed of gradually increasing cross sectional area. It means that velocity of the fluid is decreased in order to attain pressure energy. So the casing does the work of reducing the velocity of the fluid.

Working

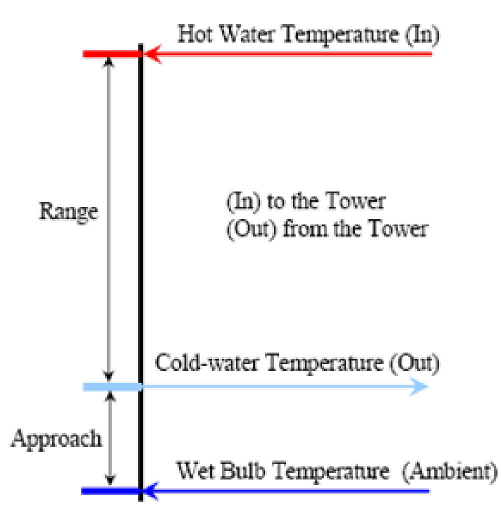
A centrifugal pump converts rotating mechanical energy to energy within the liquid being pumped. The impeller imparts velocity to the liquid.

	The liquid enters through a suction connection concentric with the axis of the impeller which rotates at high speed. Impeller has vanes in radial direction. Liquid flows outward through the vanes and exits the impeller at considerably greater velocities. The exiting liquid is collected in a spiral casing called the volute which converts the velocity head to the pressure head. The Head developed is approximately equal to the velocity energy at the periphery of the impeller.	2
b)	**Solar Photovoltaic Cell** **Construction** • Solar cell is a p-n junction diode made up of crystalline silicon(Si). • Phosphorous is used for doping the n-type layer and Boron for doping the p-type layer. • Screen printed contacts are applied to the front and rear of the solar cell. • The front end contacts are specially designed to allow maximun sunlight to fall on the semiconductor, but also accounting for minimum resistive losses. • Each Si cell generates about 0.5V. • Generally 36 cells are soldered together to produce a net 12V battery. **Working Principle of Solar Cell** When light reaches the p-n junction, electron is excited to the valance band under the condition that light energy is higher than the band gap energy, it generates the electron and holes which are equal in number in the valance and conduction band respectively. These electron hole pairs move in opposite directions to the barrier field. Electrons move towards the n-side and the hole	2 2

	is moved towards the p-side. So a voltage is set up which is known as photo voltage and when a load is connected, the current flows	
c)	**Three T`s of combustion** Combustion efficiency can be explained in terms of 3 T`s Time, temperature and turbulence. Simply stated , thermal oxidation is the effective employment of the process which provide through mixing of an organic substance with sufficient oxygen at a high enough temp. for a sufficient time to cause the organic to oxidize to the desire degree of completion . To achieve successful thermal oxidation , the thermal oxidizer must include : a) Turbulence – through mixing b) Temperature- oxidizing temperature (1200 – 1650 F) c) Time- combustion chamber residence time(0.5 – 2 secs.) The level of turbulence , the reaction temperature and the amount of time is depends on the fuel characteristics.	4
d)	**Advantages of renewable energy sources(any 2)** • Renewable energy will never run out. • It is clean and results in little to no greenhouse and net carbon emissions. • It will not deplete our natural resources and have minimal impact on environment. • It will increase nation's energy security • Switching to renewable energy sources also means steady pricing on energy. Since the cost of renewable energy is dependent on the invested money and not the increasing or decreasing or inflated cost of	2

	the natural resource. **Disadvantages of Renewable Energy(any 2)** • One shortcoming is that renewable energy relies heavily upon the weather for sources of supply: rain, wind, and sunshine. • Another disadvantage of renewable energy is that it is difficult to generate large amount of energy as those produced by coal powered plants. • Initial investments are quite high in case of building renewable energy plants. These plants require upfront investments to build, have high maintenance expenses and require careful planning and implementation. • To meet up with the large quantities of electricity produced by fossil fuels, large amount of solar panels and wind farms need to be set up. For this, large tracts of land are required to produce energy quantities competitive with fossil fuel burning.	2
4B	**Attempt any one**	**6**
a)	**Specific heat**: The specific heat is the amount of heat per unit mass required to raise the temperature by one degree Celsius. **Latent heat**: Amount of heat that changes the state of a material (from solid to liquid or liquid to gas) without raising its temperature any further. Given data T1= 100^oC T2= 60^oC λ = 540 kCal/kg Cp = 1 kCal/kg^{o}C	1 1 4

	For 2 kg steam Q = m[λ + (Cp ΔT)]= 2[540+(1x40)] = 1160 kCal = 4855.76 kJ	
b)	**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 • Conclusions and recommendations • Appendix **An executive summary**is a short document or section of a document that summarizes a longer report or proposal or a group of related reports in such a way that readers can rapidly become acquainted with a large body of material without having to read it all. It usually contains a brief statement of the audit covered in the major document(s), background information, concise analysis and main conclusions. It is intended as an aid to decision-making by managers and has been described as the most important part of aactivity.	4 2

5	**Attempt any two**	**16**
a)	The performance of cooling towers is evaluated to assess present levels of approach and range against their design values, identify areas of energy wastage and to suggest improvements. During the performance evaluation, portable monitoring instruments are used to measure the following parameters: • Wet bulb temperature of air • Dry bulb temperature of air • Cooling tower inlet water temperature • Cooling tower outlet water temperature • Exhaust air temperature • Electrical readings of pump and fan motors • Water flow rate Air flow rate These measured parameters and then used to determine the cooling tower performance in several ways. These are  	4 2

	a**) Range** . This is the difference between the cooling tower water inlet and outlet temperature. A high CT Range means that the cooling tower has been able to reduce the water temperature effectively, and is thus performing well. The formula is: CT Range (°C) = [CW inlet temp (°C) – CW outlet temp (°C)] b) **Approach** . This is the difference between the cooling tower outlet coldwater temperature and ambient wet bulb temperature. The lower the approach the better the cooling tower performance. Although, both range and approach should be monitored, the `Approach' is a better indicator of cooling tower performance. CT Approach (°C) = [CW outlet temp (°C) – Wet bulb temp (°C)] c) **Effectiveness.** This is the ratio between the range and the ideal range (in percentage), i.e. difference between cooling water inlet temperature and ambient wet bulb temperature, or in other words it is = Range / (Range + Approach). The higher this ratio, the higher the cooling tower effectiveness. CT Effectiveness (%) = 100 x (CW temp – CW out temp) / (CW in temp – WB temp) d) **Cooling capacity**. This is the heat rejected in kCal/hr or TR, given as product of mass flow rate of water, specific heat and temperature difference.	2
b)	**Simple payback period**: Payback period is the time in which the initial cash outflow of an investment is expected to be recovered from the cash inflows generated by the investment. It is one of the simplest investment appraisal	4

	techniques. ***Formula of payback period:*** $$\text{Payback period} = \frac{\text{Investment required for a project}}{\text{Net annual cash inflow}}$$ Importance: According to this method, the project that promises a quick recovery of initial investment is considered desirable. If the payback period of a project computed by the above formula is shorter than or equal to the management's maximum desired payback period, the project is accepted otherwise it is rejected. For example, if a company wants to recoup the cost of a machine within 5 years of purchase, the maximum desired payback period of the company would be 5 years. The purchase of machine would be desirable if it promises a payback period of 5 years or less. **Given data:** Investment : 2,50,000/- Annual saving : 30000/- Annual maintenance: 8000/- Simple payback period = Total investment/ (annual saving– annual maintenance) = 250000/(30000-8000) = 11.36 years	4
c)	**Throttling** Due to the dynamic nature of demand, measures are necessary to regulate flow in the system. Traditionally, this is achieved with the aid of throttles (e.g. valves). Throttles are cheap and easy to operate, but as they regulate flow by increasing the pressure drop in the system, they result in significant wastage of energy. Therefore, alternative flow regulation strategies should be explored.	3

	Impeller trimming Given data $P_1 = 8$ kW $D_2 = 0.9\ D_1$ Where D is impeller diameter P is power consumed by pump. 1 is before trimming and 2 after trimming. Power consumption at trimmed impeller $P_2 = P_1 \ x \ (D_2/D_1)^3$ $P_2 = 8 \ X\ (0.9\ D_1/D_1)^3$ [here $D_2 = 0.9D_1$] $= 8 \ x \ 0.729$ $= 5.832$ kW Reduction in power = 8-5.832 = 2.168 kW	5
6	**Attempt any two**	
a)	**Energy saving in boiler** • Reducing excess air • Installing economizer • Reducing scale and deposits • Reducing blow down • Recovering waste heat from blow down • Stopping dynamic operation • Reducing boiler pressure • Operating at peak efficiency • Preheating combustion air	1 mark each for any four

	• Switching from steam to air atomization • Switching to lower cost fuel **Energy conservation opportunities in pumping system** • Ensure adequate NPSH at site of installation • Ensure availability of basic instruments at pumps like pressure gauges, flow meters. • Operate pumps near best efficiency point. • Modify pumping system and pumps losses to minimize throttling. • Adapt to wide load variation with variable speed drives or sequenced control of multiple units. • Stop running multiple pumps - add an auto-start for an on-line spare or add a booster pump in the problem area. • Use booster pumps for small loads requiring higher pressures. • Increase fluid temperature differentials to reduce pumping rates in case of heat exchangers. • Repair seals and packing to minimize water loss by dripping. • Balance the system to minimize flows and reduce pump power requirements. • Avoid pumping head with a free-fall return (gravity); Use siphon effect to advantage: • Conduct water balance to minimise water consumption • Avoid cooling water re-circulation in DG sets, air compressors, refrigeration systems, cooling towers feed water pumps, condenser pumps and process pumps.	1 mark each for any four

b)	**Concept of Solar Cooker** A solar cooker is a device which uses the energy of direct sunlight to heat, cook or pasteurise drink. It works on following principles 1) *Concentrating sunlight*: A mirrored surface with high specular reflectivity is used to concentrate light from the sun on to a small cooking area. Depending on the geometry of the surface, sunlight can be concentrated by several orders of magnitude producing temperatures high enough to melt salt and smelt metal. For most household solar cooking applications, such high temperatures are not really required. Solar cooking products, thus, are typically designed to achieve temperatures of 150 °F (65 °C) (baking temperatures) to 750 °F (400 °C) (grilling/searing temperatures) on a sunny day. 2) *Converting light energy to heat energy*: Solar cookers concentrate sunlight onto a receiver such as a cooking pan. The interaction between the light energy and the receiver material converts light to heat. This conversion is maximized by using materials that conduct and retain heat. Pots and pans used on solar cookers should be matte black in color to maximize the absorption. 3) *Trapping heat energy*: It is important to reduce convection by isolating the air inside the cooker from the air outside the cooker. Simply using a glass lid on your pot enhances light absorption from the top of the pan and provides a greenhouse effect that improves heat retention and minimizes convection loss. This "glazing" transmits incoming visible sunlight but is opaque to escaping infrared thermal radiation. In resource constrained settings, a high-temperature plastic bag can serve a similar function, trapping air inside and making it possible to reach temperatures on cold and windy days similar to those	4

	possible on hot days. **Solar to electricity** Solar energy can be converted into electricity by two ways. *1) Solar Photovoltaic* Light striking a silicon semiconductor causes electrons to flow, creating electricity. Solar power generating systems take advantage of this property to convert sunlight directly into electrical energy. Solar panels (also called “solar modules□E produce direct current (DC), which goes through a power inverter to become alternating current (AC) — electricity that we can use in the home or office, like that supplied by a utility power company. There are two types of solar power generating systems: grid-connected systems, which are connected to the commercial power infrastructure; and stand-alone systems, which feed electricity to a facility for immediate use, or to a battery for storage. *2) Solar thermal* Solar thermal power plants use the sun's rays to heat a fluid to high temperatures. The fluid is then circulated through pipes so that it can transfer its heat to water and produce steam. The steam is converted into mechanical energy in a turbine, which powers a generator to produce electricity.The common basic principle of solar thermal power plants is the use of concentrating parabolic dish systems in large-scale solar fields that concentrate the solar radiation onto a receiver. All systems must track the sun in order to be able to concentrate the direct radiation. This radiation is first converted in a special absorber system (receiver) into thermal energy at temperatures in the range of about 200 to over 1,000 °C (depending on the system).	2 2

c)	**Direct method** This 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: Boiler Efficiency (η) = (Heat output/Heat input)x 100 Boiler Efficiency (η) =[Qx(hg-hf)/qXGCV] x 100 Parameters to be monitored for the calculation of boiler efficiency by direct method are: 1.� Quantity of steam generated per hour (Q) in kg/hr. 2,ƒ Quantity of fuel used per hour (q) in kg/hr. ƒ 3. The working pressure (in kg/cm2(g)) and superheat temperature (oC), if any 4.The temperature of feed water (oC) ƒ 5. Type of fuel and gross calorific value of the fuel (GCV) in kcal/kg of fuel And where ƒ hg – Enthalpy of saturated steam in kcal/kg of steam ƒ hf – Enthalpy of feed water in kcal/kg of water	8