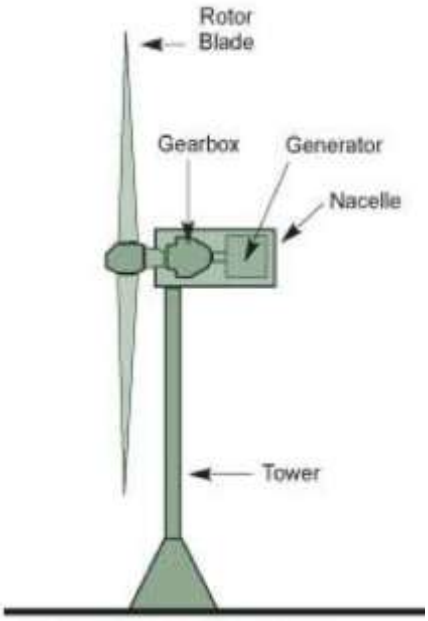
WINTER–18 EXAMINATION
Model Answer

Subject Name: Energy Management **Subject Code:** 17559

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.

Q. No.	Sub Q. N.	Answer	Marking Scheme
1	**A**	**Attempt any three of the Following**	**12**
1	a)	**Importance of Energy Conservation** 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.	4
1	b)	**Uses of 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.	2

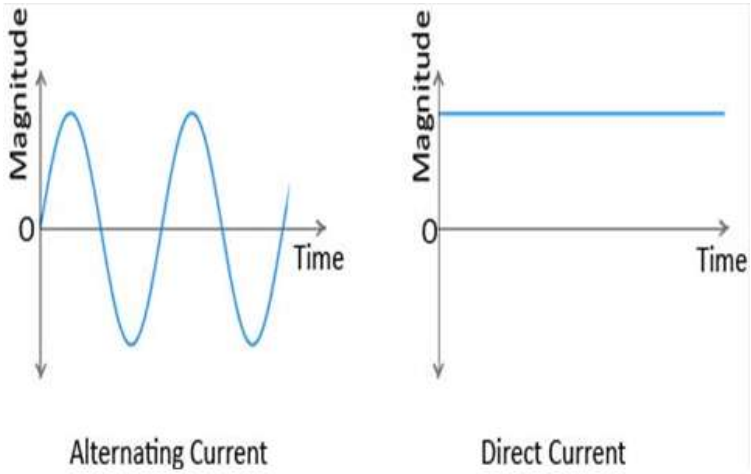
			2
1	c)	**Benchmarking Parameters** 1. kWh/MT clinker or cement produced (cement plant) 2. kWh/kg yarn produced (textile unit) 3. kWh/MT , kcal/kg, paper produced (paper plant) 4. kcal/kWh power produced (heat rate of power plant) 5. million cal/MT urea or ammonia (fertilizer plant) 6. kWh/MT of liquid metal output (in a foundry) 7. kW/ ton of refrigeration (on air conditioning plant) 8. % thermal efficiency of a boiler plant 9. % cooling tower effectiveness in a cooling tower 10. kWh/Nm^3 of compressed air generated 11. kWh/liter in a diesel power generation plant	1 mark each for any four
1	d)	**Advantages of solar energy (any two)** 1. It is renewable energy source. 2. Energy available from sun is free of cost 3. It does not create any emission 4. Its availability is more than our requirement	1 mark each for any two advantages and two dis

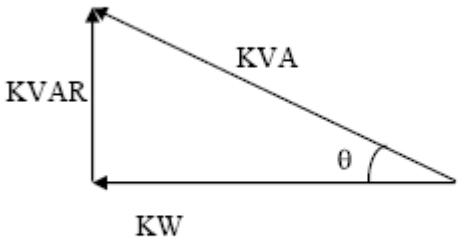
		Disadvantages of solar energy(any two) 1. It is weather dependent 2. Higher capital cost is required. 3. Energy storage is expensive 4. More land is required for solar power plant.	advantages
1	**B**	**Attempt any three of the Following**	**6**
1	a)	**Calorific value of fuel** The amount of energy produced by the complete combustion of a material or fuel. Measured in units of energy per amount of material, e.g. kJ/kg. **Difference between NCV and GCV**	2

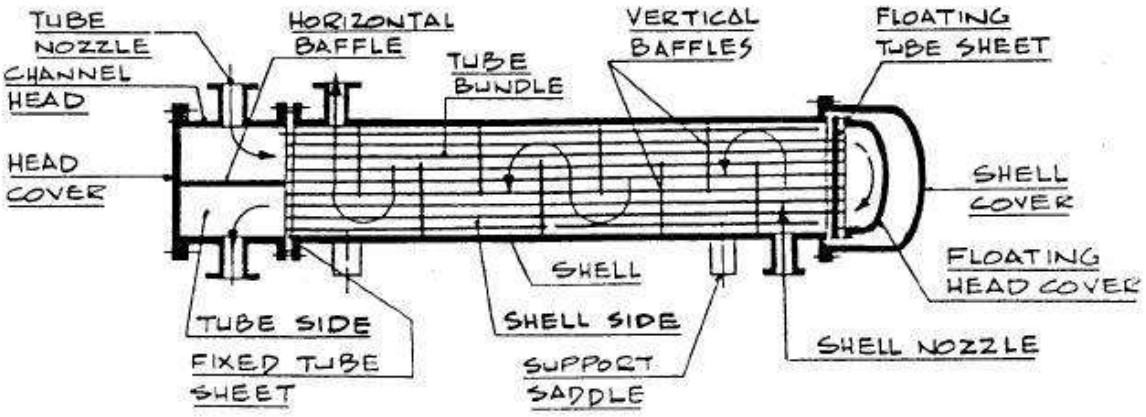
Gross Calorific Value	**Net Calorific Value**
The gross heating value is obtained when all products of the combustion are cooled down to the temperature before the combustion considering the water vapor formed during combustion is condensed.	The net or lower heating value is obtained by subtracting the latent heat of vaporization of the water vapor formed by the combustion from the gross or higher heating value.
Value is higher than NCV	Value is lower than GCV
If no hydrogen is present GCV= NCV	More hydrogen is present lower is NCV.
It is not an actual heat available for use.	It is an actual heat available for use.

4

1	b)	**Alternating Current** The current, which reverses its direction periodically in second , is called "Alternating Current". The polarity of the voltage , is reversed periodically in an Alternating Current source. So the current reverses its direction periodically. Hence the name Alternating Current (AC) indicating current is alternating (periodically). **Direct Current**	2 2

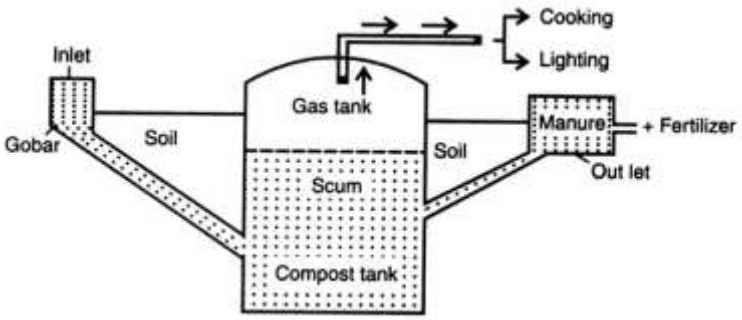
		DC (direct current) is the unidirectional flow or movement of electric charge carriers (which are usually electrons). The intensity of the current can vary with time, but the general direction of movement stays the same at all times 	2
2		**Attempt any four of the Following**	**16**
2	a)	**Structure of energy audit report** 1. Executive Summary 2. Audit objectives, scope and methodology 3. Plant Overview 4. Production Process Description 5. Energy and Utility System Description 6. Detailed Process Flow Diagram and Energy & Material Balance 7. Energy Use Analysis in Utility and Process Systems (any of the following that are applicable) 8. Energy Use and Energy Cost Analysis in the Plant 9. Energy-Efficiency Options and Recommendations 10. Conclusion and a brief action plan for the implementation of energy-efficiency options Acknowledgements Appendixes List of energy audit worksheets List of vendors for energy-efficient technologies and other technical details	4

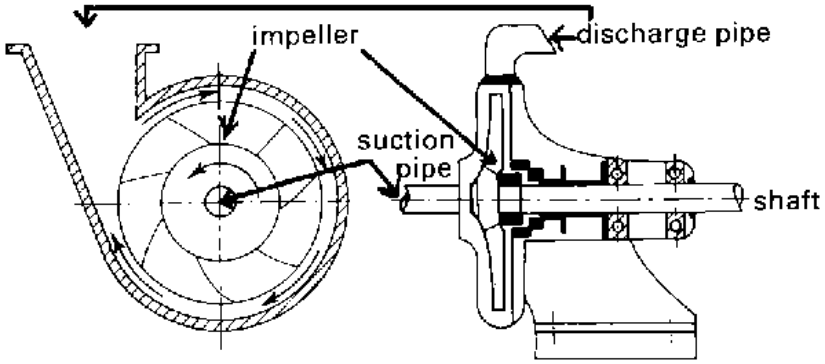
2	b)	**Features of Perform Achieve Trade (PAT)** • Specification of specific energy consumption (SEC) norm for each designated consumer in the baseline year and in the target year • Verification of the SEC of each designated consumer in the baseline year and in the target year by an accredited verification 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 each for any four
2	c)	**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. *The Power Triangle*  $P.F. = \frac{KW}{KVA} = \cos\theta$ Power Factor (PF) is the ratio between the active power (kW) and apparent power (kVA). $\text{Power Factor } (\cos\Phi) = \frac{Active\ Power\ (kW)}{Apparent\ Power\ (kVA)}$ $= \frac{kW}{\sqrt{(kW)^2 + (kVAr)^2}}$	4

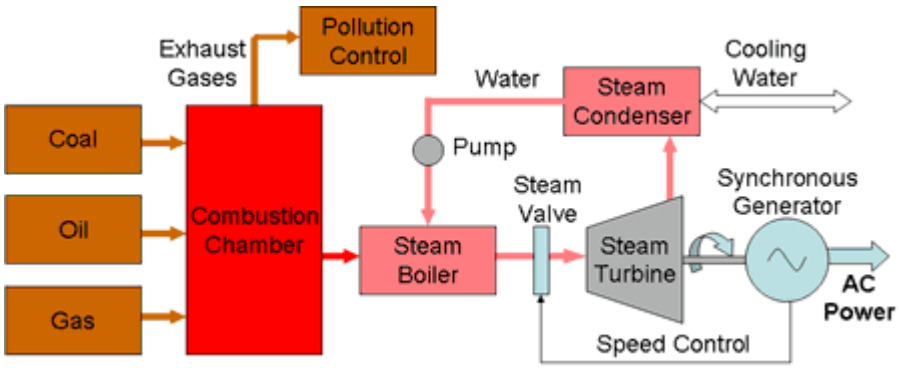
2	d)	**Shell and tube heat exchanger**  	4
2	e)	**Energy Scenario in India** • Energy is the prime mover of economic growth and is vital to the sustenance of a modern economy. • Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible and environmentally friendly. • India ranks sixth in the world in total energy consumption and needs to accelerate the development of the sector to meet its growth aspirations. • The country, though rich in coal and abundantly endowed with renewable energy in the form of solar, wind, hydro and bio-energy has very small hydrocarbon reserves (0.4% of the world's reserve). • India, like many other developing countries, is a net importer of energy, more than 25 percent of primary energy needs being met through imports mainly in the form of crude oil and natural gas. • The rising oil import bill has been the focus of serious concerns due to the pressure it has placed on scarce foreign exchange resources and is also largely responsible for energy supply shortages. The sub-optimal consumption of commercial energy adversely affects the productive sectors, which in turn hampers economic growth. • If we look at the pattern of energy production, coal and oil account for 54 percent and	4

		34 percent respectively with natural gas, hydro and nuclear contributing to the balance. In the power generation front, nearly 62 percent of power generation is from coal fired thermal power plants and 70 percent of the coal produced every year in India has been used for thermal generation.	
3		**Attempt any four of the Following**	**16**
3	a)	**Gasification of biomass** Gasification is a process that converts organic or fossil fuel based carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide. This is achieved by reacting the material at high temperatures (>700 °C), without combustion, with a controlled amount of oxygen and/or steam. A gasifier is a reactor that converts biomass into clean gaseous fuel called producer gas (having calorific value of the order of 1000–1200 kilocalories per normalized cubic metre). Biomass gasifier system optimally utilizes wood for power generation. It consists of a downdraft gasifier, a gas-cleaning train, and an engine. The technological innovation provided users with the option of dual-fuel operation. The existing diesel genset could run on both diesel and producer gas, instead of running only on diesel. The producer gas is fed into the diesel engine to let the engine operate in a dual-fuel mode, thereby reducing diesel consumption by more than 70% The resulting gas mixture is called syngas (from synthesis gas or synthetic gas) or producer gas and is itself a fuel. Syngas produced from gasifier is send to generator as afuel. Generator is used to produce power. The power derived from gasification and combustion of the resultant gas is considered to be a source of renewable energy if the gasified compounds were obtained from biomass.	4
3	b)	**Energy saving in boiler** 1. Reducing excess air 2. Installing economizer 3. Reducing scale and deposits 4. Reducing blow down	1 mark each for any four

		5. Recovering waste heat from blow down 6. Stopping dynamic operation 7. Reducing boiler pressure 8. Operating at peak efficiency 9. Preheating combustion air 10. Switching from steam to air atomization 11. Switching to lower cost fuel	
3	c)	**Detailed Energy Audit** Detailed energy audit includes a complete description of the facility, including an equipment inventory, an energy balance, detailed energy savings and costs associated with each low-cost and not-cost measure, financial analysis of each recommended measure, identification and rough estimates of capital project costs and savings. Energy savings and economic feasibility are determined as accurately as possible. The reports contain more detailed descriptions of the measures. The portable instruments, trend logs and data loggers are used in detailed energy audits for assessing the current performance accurately .The scope of an energy audit includes an examination of the following areas: Energy generation/conversions equipments like boilers, furnaces, Heaters ,pumps, fans, compressors, transformers etc. Energy distribution network of electricity, water, steam, condensate, compressed air etc. Energy utilization efficiency of all equipment and buildings. Efficient planning, operation, maintenance and housekeeping Management aspects of design and operating data collection, field measurements, data analysis, and training	4

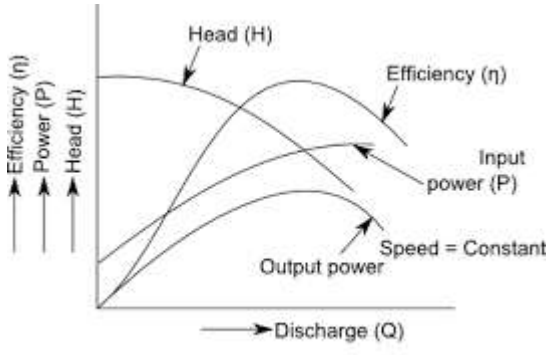
3	d)	**Biogas Plant**  	4
3	e)	**Classification of energy :** **Primary energy source** is an energy form found in nature that has not been subjected to any conversion or transformation process. The primary energy sources are derived from: the sun, the earth's heat, the wind, water (rivers, lakes, tides, and oceans), fossil fuels - coal, oil, and natural gas, biomass, and radioactive minerals. **Secondary energy source** 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. **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	2 mark each for any two
4	**A**	**Attempt any three of the Following**	**12**
4A	a)	**Constructional features of centrifugal(water) pump** Seal : Centrifugal pump can be provided with packing rings or mechanical seal which helps prevent the leakage of the pumped liquid into the atmosphere. Shaft :The main function of the shaft in a centrifugal pump is to transmit the input power from the driver into the impeller. Casing: The casing contains the liquid and acts as a pressure containment vessel that directs the flow of liquid in and out of the centrifugal pump.	4

		Impeller :Centrifugal pumps use impeller as the primary source for their pumping action. Its function is to increase the pressure of the liquid. Bearing :The function of the bearing is to support the weight of the shaft (rotor) assembly, to carry the hydraulic loads acting on the shaft, and to keep the pump shaft aligned to the shaft of the driver. Suction and discharge nozzles**:** These are inlet and outlet for pump. 	
4A	b)	**Energy generated from tide and ocean:** ***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. ***From ocean*** **Ocean thermal energy conversion (OTEC)** Is a method for generating electricity which uses the temp. difference that exist between deep	2 2

		and shallow water to run heat engine. As with any heat engine, the greatest efficiency and power is produced with the largest temp. difference. This temp difference increases with decreasing latitude. Evaporation prevent the surface temp from exceeding 27 deg. C .also the subsurface water rarely falls below 5 deg. C. The earth`s ocean are continuously heated by sun. this temp difference contains a vast amount of solar energy	
4A	c)	**Electricity generation form thermal power plant** The function of the coal fired thermal power plant is to convert the energy available in the coal to electricity. The working of a coal power plant is explained in brief: Firstly, water is taken into the boiler from a water source. The boiler is heated with the help of coal. The increase in temperature helps in the transformation of water into steam. The steam generated in the boiler is sent through a steam turbine. The turbine has blades that rotate when high velocity steam flows across them. This rotation of turbine blades is used to generate electricity. A generator is connected to the steam turbine. When the turbine turns, electricity is generated and given as output by the generator, which is then supplied to the consumers through high-voltage power lines.  	2 2
4A	d)	**Salient features of 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	1 mark each for any four features

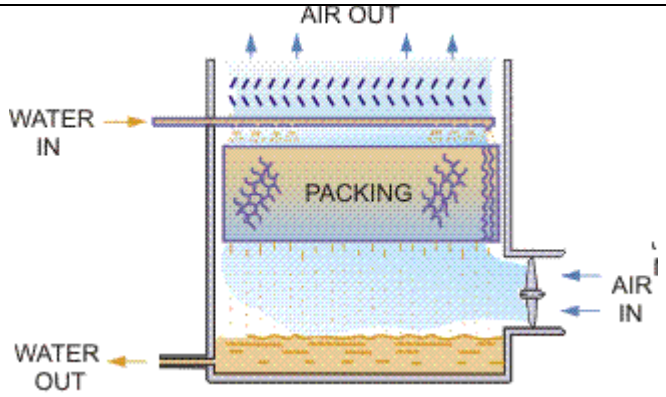
		not conforming to energy consumption standards; • notify energy intensive industries, other establishments, and commercial buildings as designated consumers; • establish and prescribe energy consumption norms and standards for designated consumers; • prescribe energy conservation building codes for efficient 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 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.	
4	**B**	**Attempt any one of the Following**	**6**
4B	a)	**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	3

		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. **Given Data** M = 25 kg deltaT= 80 – 25 = 55^{o}C Cp = 0.25 Kcal/Kg C Q= m x Cp x dT = 25 x 0.25 x 55 =343.75 Kcal	3
4B	b)	**Energy audit** An energy audit is an inspection survey an analysis of energy flows, for energy conservation in a building, process or system to reduce the amount of energy input into the system without negatively affecting the output. **Energy cost** Understanding energy cost is vital factor for awareness creation and saving calculation. In many industries sufficient meters may not be available to measure all the energy used. In such cases, invoices for fuels and electricity will be useful. The annual company balance sheet is the other sources where fuel cost and power are given with production related information. Energy invoices can be used for the following purposes: • It provide a record of energy purchased in a given year, which gives a base-line for future reference • Energy invoices may indicate the potential for savings when related to production requirements or to air conditioning requirements/space heating etc. • When electricity is purchased on the basis of maximum demand tariff It can suggest where savings are most likely to be made. • In later years invoices can be used to quantify the energy and cost savings made	2 4

		through energy conservation measures	
5	**A**	**Attempt any two of the Following**	**16**
5	a)	**Characteristics Curve of Pump** The characteristic curves of centrifugal pumps plot the course of the following parameters against flow rate(Q): head (H) (see H/Q curve), power input (P), pump efficiency (η) and NPSHr, i.e. the NPSH required by the pump. The characteristic curve's shape is primarily determined by the pump type (i.e. impeller, pump casing or specific speed. Secondary influences such as cavitation, manufacturing tolerances, size and physical properties of the fluid handled (e.g. viscosity, solids transport or pulp pumping are not taken into account in these diagrams. For the normal operating range of centrifugal pumps (n, Q and H all positive), it is sufficient to plot the characteristic curve in the first quadrant of the H/Q coordinate system. As the specific speed increases, the (negative) slope of the H/Q curve becomes steeper. The power input curve of a low specific speed pump has its minimum value at Q = 0 (shut-off point), whereas the power input of a high specific speed pump reaches a maximum at Q = 0. The presentation of parameters in a characteristic curve can provide Qualitative information Quantitative information on existing centrifugal pumps of various specific speeds  Operating characteristic surves of a pump. **Energy conservation opportunities in pumping system (any four** • Ensure adequate NPSH at site of installation	4 4

		• 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.	
5	b)	**Importance of payback period** 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. **ENCON recommendations (any six)** • Eliminate throttling of a pump by impeller trimming, resizing pump, installing variable speed drives • Eliminate damper operations in fans by impeller trimming, installing variable speed drives, pulley diameter modification for belt drives, fan resizing for better efficiency.	2 1 mark each for any six

		• Moderation of chilled water temperature for process chilling needs • Recovery of energy lost in control valve pressure drops by back pressure/turbine adoption • Adoption of task lighting in place of less effective area lighting • Eliminate steam leakages by trap improvements • Maximise condensate recovery • Adopt combustion controls for maximizing combustion efficiency • Replace pumps, fans, air compressors, refrigeration compressors, boilers, furnaces, heaters and other energy consuming equipment, wherever significant energy efficiency margins exist.	
5	c)	**Cooling towers** **Mechanical draft cooling towers** Unlike natural draft cooling towers, mechanical draft cooling towers employ fans or other mechanics to circulate air through the tower. Common fans used in these towers include propeller fans and centrifugal fans. Mechanical draft towers are more effective than natural draft towers, and can even be located inside a building when exhausted properly. However, they consume more power than natural draft cooling towers and cost more to operate as a result. *Induced draft cooling tower* Cooling water returns in a warm state from the process and enters at the top of the cooling tower under pressure to be distributed through the fill pack. Simultaneously, air is drawn in at the base of the tower by the fan and travels upward to mix with the water where some evaporation takes place, removing heat from the remainder. The warm moist air is discharged to atmosphere.	2



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Forced draft cooling tower

The forced draft cooling towers remove low-potential heat generated in the production process. They use atmospheric cooling with wet technology and forced draft. A counterflow of air and hot water in the cooling fill results in a heat transfer. Fan is provided at the top of tower which suck the air into the tower. Air congaing heat and moisture exit from the top of tower.

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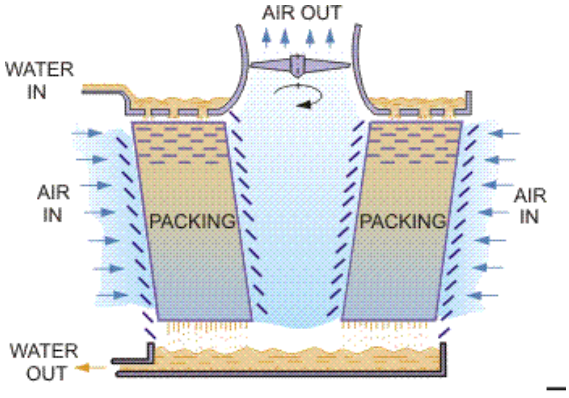

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Note: Marks can be given for any other type also

6		**Attempt any two of the Following**	**16**
6	a)	**Performance assessment of H.E.:** Step A: Monitoring and reading of steady state parameters of the H.E. under evaluation are tabulated as below:	8

parameters	units	inlet	Outlet
Hot fluid flow	Kg/h		
Cold fluid flow	Kg/h		
Hot fluid temp.	Deg. C		
Cold fluid temp.	Deg. C		
Hot fluid P	Bar g		
Cold fluid P	Bar g		

Step B:physical properties of stream can be tabulated as:

parameters	unit	Inlet	outlet
Hot fluid density	Kg/h		
Cold fluid density	Kg/h		
Hot fuid viscosity	MPas		
cold fuid viscosity	MPas		
Hot fuid them. coductivity	kW/(mK)		
Cold fuid ther. conductivity	kW/(mK)		
Hot fuid heat capacity	KJ/Kg.K		
Cold fuid heat capacity	KJ/Kg.K		

Step c:

Calculate the thermal parameters of H.E. & compare with the design data:

parameters	Unit	Test date	Design data
Heat duty	kW		
Hot fluid side P drop	Bar		
Cold fluid side P drop	Bar		
Temp. Range hot fluid	Deg. C		
Temp. Range cold fluid	Deg. C		
Capacity ratio , R	-		
Effectiveness , S	-		
Corrected LMTD	Deg. C		
H.T.Coeff. , U	KW/(m^2.K)		

Step D:

1) heat duty , $Q = Q_s + Ql$

Qs = sensible heat , Ql = latent heat

For sensible heat

Qs = (m x Cp x dT)hf

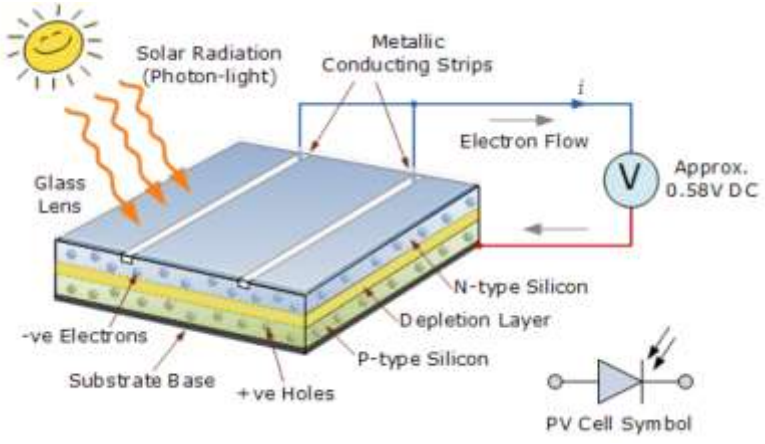
Qs =(m x Cp x dT)cf

For latent heat

Ql = (m x latent heat)hf

Ql = (m x latent heat)cf

		2) Hot fluid side P drop , (dP)hf = Pi –Po 3) Cold fluid side P drop , (dP)cf = Pi –Po 4) Temp. Range hot fluid , dT = Ti - To 5) Temp. Range cold fluid , dt = ti – to 6) Capacity ratio , R = (Ti- To) / (to – ti) 7) Effectiveness , S = (to- ti) / (Ti –ti) 8) LMTD: LMTD for counter current flow LMTD for co-current flow Correction factor for LMTD, $F = \frac{(R+1)^{1/2} \times \ln[(1 - S R)/(1 - S)]}{(1 - R) \times \ln\{2 - S[R + 1 - (R+1)^{1/2}] / 2 - S[R + 1 + (R+1)^{1/2}]\}}$ 9) Corrected LMTD = F x LMTD 10) Overall heat transfer coeff. , U = Q / (A x Corrected LMTD)	
6	b)	**Boiler efficiency 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(h_g-h_f)/q X GCV] x 100 Parameters to be monitored for the calculation of boiler efficiency by direct method are: 1.ƒ Quantity of steam generated per hour (Q) in kg/hr. 2. Quantity of fuel used per hour (q) in kg/hr. 5. Calorific value of the fuel (GCV) in kcal/kg of fuel 6. h_g – Enthalpy of saturated steam in kcal/kg of steam 7. h_f – Enthalpy of feed water in kcal/kg of water	8
6	c)	**Advantages of renewal energy sources (four)**	½ mark

		1. It can renew again and again 2. Total available potential is more than requirement. 3. Fuel cost is zero 4. It does not emitted pollutant gases. 5. Combination of different forms can give 24 hours energy. **Advantages of renewal energy sources (four)** 1. It is dependent on weather 2. Capital cost is higher. 3. Research is required to increase efficiency of conversion renewable to electricity 4. Use of more land sea shore is a concern. 5. Natural calamity can destroy power plant.	each for any four advantages and dis advantages
		Solar Photovoltaic Solar Photovoltaic (PV) is a technology that converts sunlight (solar radiation) into direct current electricity by using semiconductors. When the sun hits the semiconductor within the PV cell, electrons are freed and form an electric current. These are called as solar cell. Conversion of light energy in electrical energy is based on a phenomenon called photovoltaic effect. When semiconductor materials are exposed to light, the some of the photons of light ray are absorbed by the semiconductor crystal which causes a significant number of free electrons in the crystal. This is the basic reason for producing electricity due to photovoltaic effect. Solar Panel consists of solar cell produces electricity which can stored in to battery or connected to grid.	2
			2