Maharashtra Board of Technical Education

Model Answer paper Winter-2012

Energy Management (12205)

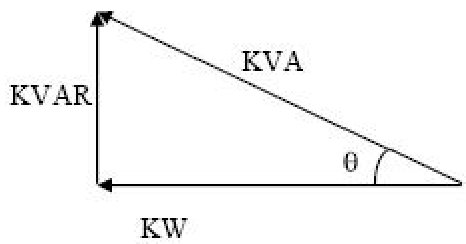
Q. No	Answer	Remarks
1.(A) a)	The basic aim of energy security for a nation is to reduce its dependency on the imported energy sources for its economic growth. Imports of oil and coal have been increasing at rates of 7% and 16% per annum respectively. Estimates indicate that oil imports will meet 75% of total oil consumption requirements and coal imports will meet 22% of total coal consumption requirements. The imports of gas and LNG (liquefied natural gas) are likely to increase in the coming years. This energy import dependence implies vulnerability to external price shocks and supply fluctuations, which threaten the energy security of the country. Increasing dependence on oil imports means reliance on imports from the Middle East, a region susceptible to disturbances and consequent disruptions of oil supplies. This requires diversification of energy. The need to deal with oil price fluctuations also necessitates measures to be taken to reduce the oil dependence of the economy, possibly throughrenewable energy. 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 Although all these options are feasible, their implementation will take time. Also, for countries like India, reliance on stockpiles would tend to be slow because of resource constraints. Besides, the market is not sophisticated enough or the monitoring agencies experienced enough to predict the supply situation in time to take necessary action. Insufficient storage capacity is another cause for worry and needs to be augmented, if India has to increase its energy stockpile. However, out of all these options, the simplest and the most easily attainable is reducing demand through persistent energy conservation efforts.	4
b)	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	2+1+1

	this ratio, the higher the cooling tower effectiveness. CT Effectiveness (%) = 100 x (CW temp – CW out temp) / (CW in temp – WB temp) Where a**) Range** 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** 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)	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. **Fuel Costs** A wide variety of fuels are available for thermal energy supply. Few are listed below: Coal LDO LSHS Natural gas Understanding fuel cost is fairly simple and it is purchased in Tons or Kiloliters. Availability, cost and quality are the main three factors that should be considered while purchasing. The following factors should be taken into account during procurement of fuels for energy efficiency and economics. • Price at source, transport charge, type of transport • Quality of fuel (contaminations, moisture etc) • Energy content (calorific value) **Power Costs** Electricity price in India not only varies from State to State, but also city to city and consumer to consumer though it does the same work everywhere. Many factors are involved in deciding final cost of purchased electricity such as: • Maximum demand charges, kVA	2+1+1

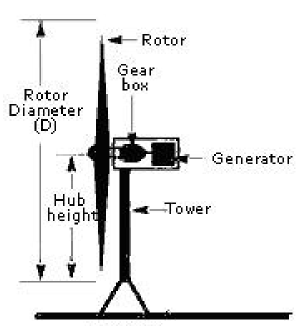
	(i.e. **How fast** the electricity is used?) Energy Charges, kWh (i.e., **How much** electricity is consumed?) • TOD Charges, Peak/Non-peak period (i.e. **When** electricity is utilized ?) • Power factor Charge, P.F (i.e., **Real power use versus Apparent power use factor**)	
d)	Energy monitoring and targeting is primarily a management technique that uses energy information as a basis to eliminate waste, reduce and control current level of energy use. It also used to improve the existing operating procedures. It builds on the principle "you can't manage what you don't measure". It essentially combines the principles of energy use and statistics. Merits • Identify and explain excessive energy use • Detect instances when consumption is unexpectedly lower than would usually have been the case • Draw energy consumption trends (weekly, seasonal, operational…) • Determine future energy use when planning changes in the business • Diagnose specific areas of wasted energy • Observe how the business reacted to changes in the past • Develop performance targets for energy management programs • Manage their energy consumption, rather than accept it as a fixed cost that they have no control over	2+2
(B) a)	Energy conservation is many times understood as a cut in energy consumption but actually it is a cut in the misuse/waste of energy. Successful firms concentrate on efficiency first, products second, and then on marketing and sales. Revenue expansion based on efficient operations results in severe operating losses. Successful companies reduce cost to watch existing revenue levels. Unsuccessful companies attempt to increase revenue to cover existing costs. 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 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. Energy cost is a significant factor in economic activity, on par with factors of production like capital, land and labor. 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	6

	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. But on an average the energy cost in CPI lies between 10-12 % of the total manufacturing cost. Therefore, energy cost reduction can play a significant role in increasing the profitability of any CPI. On an average the net profit of a company is around 3% of revenue. For companies having utility cost as 10% of revenue, a saving of 20% in utility consumption can result in an increase of profit by 66%!	
b) i) ii)	Latent heat of evaporation is the energy required to transform a given quantity of a substance from a liquid phase into a gas phase at a given pressure. Its unit is KJ/kg or Kcal/Kg. Given Data M= 10 Kg T1= 100 °C T2= 70 °C Cp =4.187 KJ/Kg °C Hv=200 KJ/Kg Heat given out = M X [Hv + CpX(T2-T1)] = 10 X [200 + 4.187 X(100-70)] = 3256.1 KJ	2 4
2 a)	Renewable energy • Renewable sources of energy mean we can renew them. • They are not exhaustible like coal or petroleum. • Renewable energy is clean energy and non-polluting • They are present in all nations in various forms. • e.g. Solar, Wind , Tidal , Ocean thermal , biomass, hydro Non renewable energy sources • These are exhaustible energy sources. • Once it is used it vanishes. • Today's most of the energy is available from non renewable energy sources. • Nonrenewable energy sources come out of the ground as liquids, gases and solids. • Right now, crude oil (petroleum) is the only naturally liquid commercial fossil fuel. • Natural gas and propane are normally gases, and coal is a solid. • Coal, petroleum, natural gas, and propane are all considered fossil fuels because they formed from the buried remains of plants and animals that lived millions of years ago. • Uranium ore, a solid, is mined and converted to a fuel. • These energy sources are considered nonrenewable because they can not	2+2

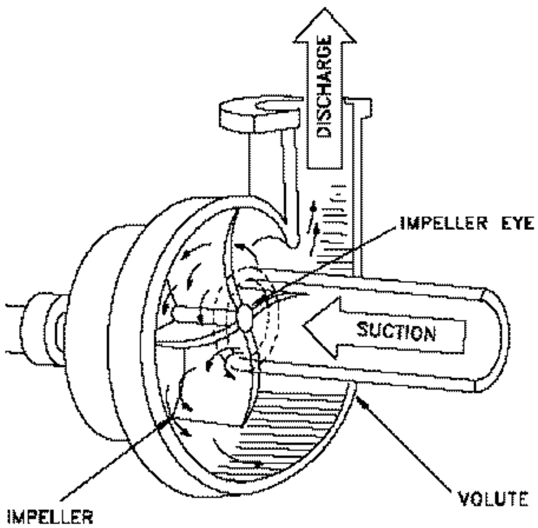
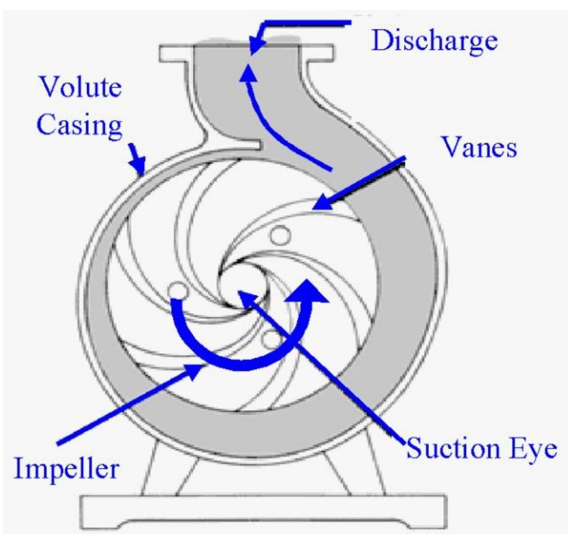
	be replenished (made again) in a short period of time.	
b)	**Conduction:** Conduction is the transfer of thermal energy from a region of higher temperature to a region of lower temperature through direct molecular communication within a medium or between mediums in direct physical contact without a flow of the material medium. The transfer of energy could be primarily by elastic impact as in fluids or by free electron diffusion as predominant in metals or phonon vibration as predominant in insulators. In other words, heat is transferred by conduction when adjacent atoms vibrate against one another, or as electrons move from atom to atom. e.g : Heating metal rod **Convection:** Convection is a combination of conduction and the transfer of thermal energy by fluid circulation or movement of the hot particles in bulk to cooler areas in a material medium. Unlike the case of pure conduction, now currents in fluids are additionally involved in convection. This movement occurs into a fluid or within a fluid, and cannot happen in solids. In solids, molecules keep their relative position to such an extent that bulk movement or flow is prohibited, and therefore convection does not occur. e.g : Boiling liquids **Radiation:**Radiation is the transfer of heat through electromagnetic radiation. Hot or cold, all objects radiate energy at a rate equal to their emissivity times the rate at which energy would radiate from them if they were a black body. No medium is necessary for radiation to occur; radiation works even in and through a perfect vacuum. The energy from the Sun travels through the vacuum of space before warming the earth. Also, the only way that energy can leave earth is by being radiated to space. e.g Sunrays radiation on earth	1+1+1+1(for examples)
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). $\text{Power Factor } (\cos\Phi) = \dfrac{\textit{Active Power } (kW)}{\textit{Apparent Power } (kVA)}$ $= \dfrac{kW}{\sqrt{(kW)^2 + (kVAr)^2}}$	2+2

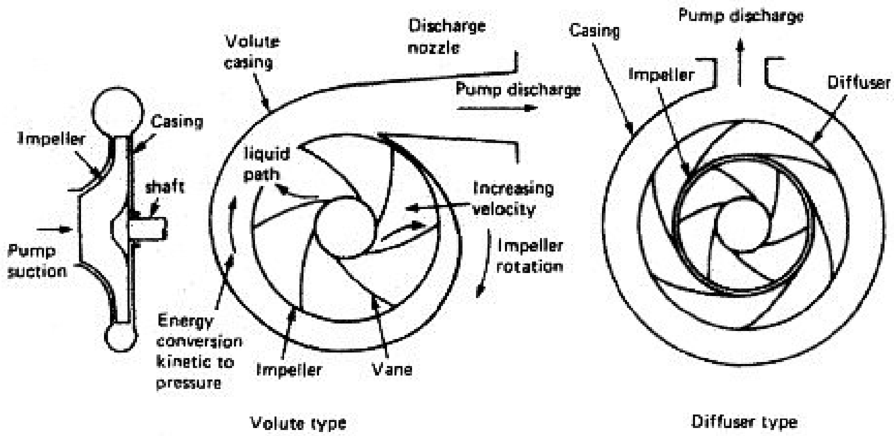
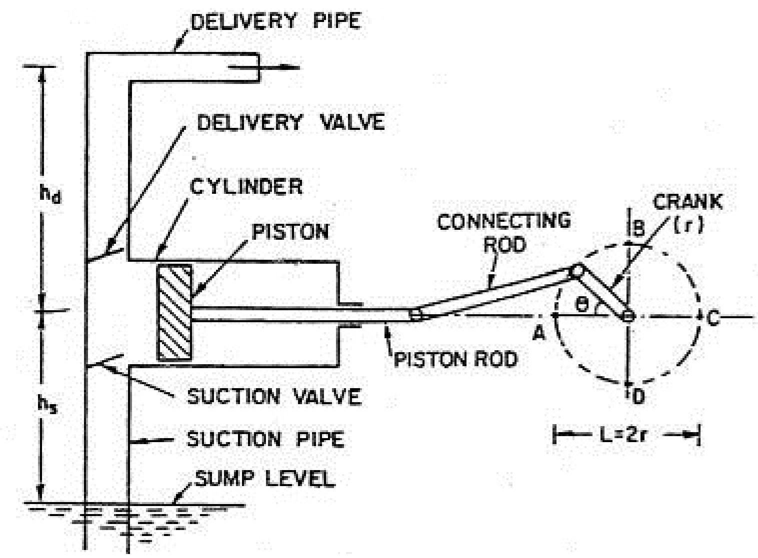
	The Power Triangle  $$\text{P.F.} = \frac{KW}{KVA} = \cos\theta$$	
d)	**Solar water heating**: Solar water heaters are used to heat water by using flat plate collectors. **Solar distillation**: The incident solar radiation is transmitted through the glass cover and is absorbed as heat by a black surface in contact with the water to be distilled. The water is thus heated and gives off water vapour. The vapour condenses on the glass cover, which is at a lower temperature because it is in contact with the ambient air, and runs down into a gutter from where it is fed to a storage tank. **Solar Cookers:** The incoming solar radiation falls onto the double glass lid and passes through it to strike the blackened cooking pots and the cooking tray. The heat is absorbed by the blackened surface and gets transferred to the food inside the pots to facilitate cooking. **Solar Pumping:** The power generated by solar cells is used for operating DC surface centrifugal mono-block pump set for lifting water from bore / open well or water reservoir for minor irrigation and drinking water purpose**.** **(Above are four examples. There are many more. Marks should be given to any correct application.)**	1 mark for each application.
e)	**Energy Audit** An energy audit is usually one of the first steps in an energy management programme. It shows how efficiently energy is being used and highlights opportunities for energy cost savings. It can also show ways to improve productivity. Energy audits take a thorough look at particular facilities, processes or technologies. Type of Energy Audit i) Preliminary Audit ii) Detailed Audit **Need of energy audit** • In any industry, the three top operating expenses are often found to be energy (both electrical and thermal), labour and materials. If one were to relate to the manageability of the cost or potential cost savings in each	1+3

	of the above components, energy would invariably emerge as a top 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 any industry, and help in identifying the areas where waste can occur and where scope for improvement exists. • The Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance 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 energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc. • In general, Energy Audit is the translation of conservation ideas into realities, by lending technically feasible solutions with economic and other organizational considerations within a specified time frame. • The primary objective of Energy Audit is to determine ways to reduce energy consumption per 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 planning a more effective use of energy throughout the organization.	
f)	**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 34 percent respectively with natural gas, hydro and nuclear contributing to the balance. In the power generation front, nearly	4

	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 a)	One kg of fuel requires a certain minimum of ambient air to be fully combusted. We call this minimum amount of air the “stochiometric air” or sometimes also “the theoretical air” to combust the fuel. The stochiometric air would completely combust the fuel to Carbon Dioxide (CO2), water (H2O), and Sulfur Dioxide (SO2) if Sulfur is present. If the fuel does not get enough air for combustion it will generate smoke and a potential unhealthy mixture of stack gas products. In addition energy is wasted. The same applies if too much excess air is used for combustion. A less trivial issue in combustion technology is therefore to ensure the proper amount of air that minimizes environmental impact and fuel consumption. The stoichiometric ratio is the perfect ideal fuel ratio where the chemical mixing proportion is correct. When all fuel and air burned is consumed without any excess left over. If an insufficient amount of air is supplied to the burner, unburned fuel, soot, smoke, and carbon monoxide exhausts from the boiler - resulting in heat transfer surface fouling, pollution, lower combustion efficiency, flame instability and a potential for explosion. To avoid inefficient and unsafe conditions boilers normally operate at an excess air level. This excess air level also provides protection from insufficient oxygen conditions caused by variations in fuel composition and insufficient mixing.It helps to burn fuel completely.	4
b)	Wind power plants are of two types according to their size. A bigger plants having capacity in MW are grid connected. Smaller plants having capacity in KW uses battery to store energy. For both types of power plants wind mill is required. It converts mechanical energy into electrical energy by using alternator or generator. Working of of wind mill is shown as  • Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. • Small turbines are pointed by a simple wind vane, while large turbines	2+ 2 (diagram)

	generally use a wind sensor coupled with a servo motor. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator. • Since a 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.	
c)	Heat exchangers are classified according to flow are 1. Counter current heat exchangers: - Fluid flow in opposite direction. 2. Parallel flow exchangers: - Flow of fluid in same direction. 3. Cross current exchanger: - Flow of fluid is in cross direction Classification according to construction 1. Double pipe heat exchangers 2. Shell and tube heat exchangers 3. Fin tube heat exchangers 4. Spiral heat exchangers 5. Plate heat exchangers	2+2
d)	Cooling towers are heat removal devices used to transfer process waste heat to the atmosphere. Cooling towers may either use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature or, in the case of closed circuit dry cooling towers, rely solely on air to cool the working fluid to near the dry-bulb air temperature. Common applications include cooling the circulating water used in oil refineries, petrochemical and other chemical plants, thermal power stations and HVAC systems for cooling buildings With respect to drawing air through the tower, there are three types of cooling towers **Natural draft** :Utilizes buoyancy via a tall chimney. Warm, moist air naturally rises due to the density differential compared to the dry, cooler outside air.. **Mechanical draft**: Uses power-driven fan motors to force or draw air through the tower. **Induced draft**: A mechanical draft tower with a fan at the discharge (at the top) which pulls air up through the tower. The fan induces hot moist air out the discharge. **Forced draft**: A mechanical draft tower with a blower type fan at the intake.	1+2+1

	The fan forces air into the tower, creating high entering and low exiting air velocities. **Fan assisted natural draft**: A hybrid type that appears like a natural draft setup, though airflow is assisted by a fan. **types by air-to-water flow** • Cross flow • Counter flow	
e)	  	(Any one) 4 marks

	 	
4 (A) a)	Given data C= 86 % H= 4 % O_2= 4.5 % Ash = 5.5 % For 1 Kg coal C= 0.86 Kg H= 0.04 Kg O_2= 0.045 Kg Ash = 0.055Kg Reactions	Reaction 1 O_2 requirement 3 Vol comp 2

$C + O_2 = CO_2$
$H_2 + 0.5O_2 = H_2O$

For 1 kgmol carbon 1 kgmol of oxgen required
For 12 kg carbon 32 kg oxygen is required
For 0.86 Kg carbon 2.293 Kg oxygen is reuired
From 0.86 kg carbon 3.153 kg CO_2 is produced

For 1 kgmol of hydrogen 0.5 kgmol of oxygen is required
For 2 kg of hydrogen 16 kg of oxygen is required
For 0.04 kg hydrogen 0.32 Kg of oxygen is required
From 0.04 kg oxygen 0.36 kg water is produced

Total oxygen required = 2.293 +0.32 -0.045 = 2.568
Supplied oxygen = 2.568*1.5= 3.852 Kg = 0.1203 Kgmol
Oxygen remained in flue gas = 3.852 -2.568 =1.284

Air supplied (21% oxygen by volume) = 0.1203/0.21=0.5728 Kgmol
Nitrogen in air = 0.5728 * 0.79 = 0.4525 Kgmol

Flue gas composition

Component	**Mass**	**Mole**	**Mole or Vol Comp (%)**
CO_2	3.153	0.07165	12.36
H_2O	0.36	0.02	3.423
O_2	1.248	0.0401	6.86
N_2		0.4525	77.44
Total		0.58425	

b) Given data
Mh= 0.4 kg/sec
Th1=450 °C
Th2= 150 °C
Cpgas=1.130 KJ/kg K
Mc = 0.45 Kg/sec
Tc1 = 15 °C
Cp water = 4.187 KJ/kg K
Uo = 1504.2 W/m^2 K =1.5042 KJ/sec m2 K

Mh X Cp gas X (Th1-Th2) =Q = 0.4 *1.13*300 =135.6 KJ/sec
Mc X Cp water X (Tc2-Tc1) =Q
0.45*4.187*(Tc2-15) =135.6 KJ/sec
Tc2 = 89.96 °C
Q = U X A X LMTD

LMTD = (Th1-Tc1) – (Th2-Tc2)/ [ln(Th1-Tc1) – (Th2-Tc2)]
= 189.37 °C

Q = 1mark
Tc2 =1mark
LMTD = 2 marks
A =2 marks

	Area = A = Q/LMTD X Uo A= 135.6/ 1.5042 * 189.37 A= 0.476 m^2	
(B) a)	Fuels can be classified according to its state at room temperature and its renewability By its state 1. Solid fuels: - These are solid at room temperature . These fuels are contain mainly hydrogen, carbon ,. Sulfurs and ash. More excess air is required compared to other fuels. E.g. Coal, biomass, crop waste, wood etc. 2. Liquid fuels: - It is liquid at room temperature. Most of the fuels are not containing ash. These are mainly petroleum products. E. g. Fuel oil. LDO, Gasoline, Diesel etc. 3. Gaseous fuels: - Cleanest fuels available in gaseous state at room temperature. E.g CNG, LPG, Biogas, Water gas By its renewability 1. Renewable fuel :- It can be renowned. Like biomass, wood etc. 2. Non renewable fuel :- Once used it is exhausted peremenatly. E.g. Coal, Petroleum	3+1
b)	**The benchmark parameters can be:** • Gross production related e.g. kWh/MT clinker or cement produced (cement plant) e.g. kWh/kg yarn produced (Textile unit) e.g. kWh/MT, kCal/kg, paper produced (Paper plant) e.g. kCal/kWh Power produced (Heat rate of a power plant) e.g. Million kilocals/MT Urea or Ammonia (Fertilizer plant) e.g. kWh/MT of liquid metal output (in a foundry) • **Equipment / utility related** e.g. kW/ton of refrigeration (on Air conditioning plant) e.g. % thermal efficiency of a boiler plant e.g. % cooling tower effectiveness in a cooling tower e.g. kWh/NM3 of compressed air generated e.g. kWh /litre in a diesel power generation plant.	Any four 4 marks
c)	Disadvantages of tidal plant • Variations in tidal range cause the output to not uniformed throughout the day. • Because of the variation of headwater throughout the day, the plants effectiveness is slightly compromised. • Maintenance of machinery is difficult when preformed underwater or at	4

	sea. • Construction of a solid tidal dam is difficult with tide changes. • The corrosives nature of seawater is proven to corrode untreated modern machinery. • Tidal fences in order to mitigate fish migration would be difficult to construct and maintain. • Generation posts are usually far away from collection stations, leading to high cost of transmission lines. • Tidal is a time-specific base load, meaning it cannot conform to peak demands. • Plat can be damaged during tsunami.	
d)	**Reduce Operating and Maintenance Costs** Performance testing can help to reduce energy costs by identifying poor efficiency and decrease maintenance costs by diagnosing chronic pump problems. How often do pumps operate away from their design point? How much power is being wasted? How do these conditions impact pump reliability and repair costs? Using ultrasonic flow meters, ammeters, and pressure instruments to determine the true performance of a pumping system can be evaluated. These tools, we help customers verify pump performance, evaluate system efficiency, and troubleshoot flow related problems. **Increase Efficiency** Roughly 20% of the power is consumed by pumps. Municipal water systems, pipelines, power plants, and many other process industries rely upon pumps to keep their operations running. In these plants, pumping systems are typically the largest source of power consumption. First, many pumps are incorrectly sized for their service conditions, resulting in very low efficiency. Simple retrofits are often available that can yield efficiency gains of 10% or more. Second, pumps often continue in service without mechanical failure, long after they are worn out and inefficient. Rebuilding this equipment to reclaim internal clearances can dramatically boost efficiency. Third, hydraulic cavitation reduces pump efficiency. Cavitation can be eliminated through improvements to the pump suction system or hydraulic changes to the pump design. **Diagnose Pump Problems** Performance testing can also be used to solve pump problems and reduce maintenance costs. Pumps are designed to operate near a specific flow rate-the BEP (Best Efficiency Point). Flow values significantly below or above BEP often result in poor reliability, cavitation, impeller and case damage, high maintenance costs, and wasted energy.	4
e)	The **Dry Bulb** temperature, usually referred to as air temperature, is the air	1+1+2

	property that is most common used. The Dry Bulb Temperature refers basically to the ambient air temperature. It is called "Dry Bulb" because the air temperature is indicated by a thermometer not affected by the moisture of the air.Dry-bulb temperature - T_{db}, can be measured using a normal thermometer freely exposed to the air but shielded from radiation and moisture. **Wet Bulb** temperature is the temperature of adiabatic saturation. This is the temperature indicated by a moistened thermometer bulb exposed to the air flow. Wet Bulb temperature can be measured by using a thermometer with the bulb wrapped in wet muslin. The adiabatic evaporation of water from the thermometer and the cooling effect is indicated by a "wet bulb temperature" lower than the "dry bulb temperature" in the air. The wet bulb temperature is always lower than the dry bulb temperature but will be identical with 100% relative humidity **The maximum cooling tower efficiency depends on the wet-bulb temperature of the air** Cooling towers use the principle of evaporative cooling in order to cool water. they can achieve water temperatures below the dry bulb temperature - tdb - of the air used to cool it they are in general smaller and cheaper for the same cooling load than other cooling systems Cooling towers are rated in terms of approach and range. The approach is the difference in temperature between the cooled-water temperature and the entering-air wet bulb - twb - temperature. The range is the temperature difference between the water inlet and exit states.	
5 (A)	Throttleing is required when we require a less flowrate than design. It is waste of energy. We can use following options to avoide trotteling. **1) Impeller Trimming** :- Changing the impeller diameter gives a proportional change in the impeller's peripheral velocity. Similar to the affinity laws, the following equations apply to the impeller diameter D: $\mathbf{Q \propto D}$ $\mathbf{H \propto D^2}$ $\mathbf{P \propto D^3}$ Changing the impeller diameter is an energy efficient way to control the pump flow rate. However, for this option, the following should be considered: • This option cannot be used where varying flow patterns exist. • The impeller should not be trimmed more than 25% of the original impeller size, otherwise it leads to vibration due to cavitation and therefore decrease the pump efficiency. • The balance of the pump has to been maintained, i.e. the impeller trimming should be the same on all sides.	1X4

	2) Changing Speed:- Speed of pump can be change by using variable speed drive. According to affinity laws $$Q \propto N$$ $$H \propto N^2$$ $$P \propto N^3$$ Where: Q = Flow rate H = Head P = Power absorbed N = Rotating speed Efficiency is essentially independent of speed **3) Using smaller capacity pump:-** Bigger pump draws more power even if valve is used to reduce flow. It is better to use small capacity pump for less capacity. **4) Can use multiple pump arrangement :-** combination of pump with various capacities to get required flow rates.	
(B)	LMTD Parallel flow = (Thin-Tcin) – (Thout-Tcout)/ [ln(Thin-Tcin) – (Thout-Tcout)] Conunter flow = (Thin-Tcout) – (Thout-Tcin)/ [ln(Thin-Tcout) – (Thout-Tcin)]	2+2
(C)	Mh=1000 Kg/hr Cpoil= 2.09 KJ/kg K Thin= 80 oC Thout= 40 oC Mc = 1000 Kg/hr Tcin = 30 oC Cpwater =4.187 KJ/Kg K U = 24 W/m2K=86.4 KJ/hr m^2 K Q=Mc*Cpoil* (Thin-Thout)=Mc*Cpwater*(Tcout-Tcin) Q=83600 KJ/hr Tcout = 49.96 oC **(it is not corrcet practically)** **(LMTD for parallel can not be find out.If student solve the problem up to this level should be considred positively)** LMTD for counter flow=18.19 oC As LMTD is more parallel flow scheme is chosen. Q= U*A*LMTD Putting above values A= 53.04 m^2	4

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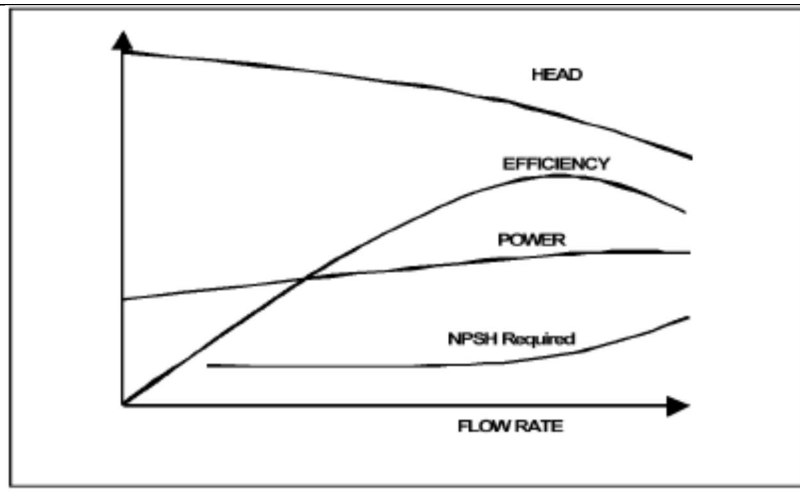
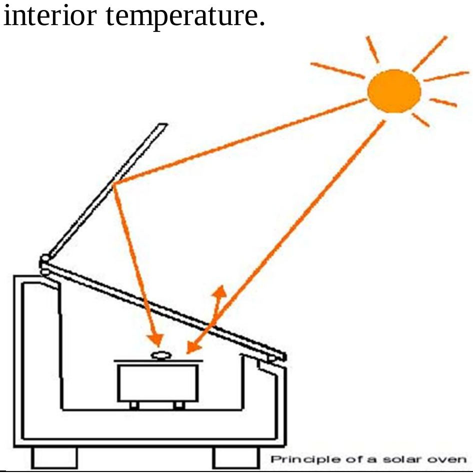
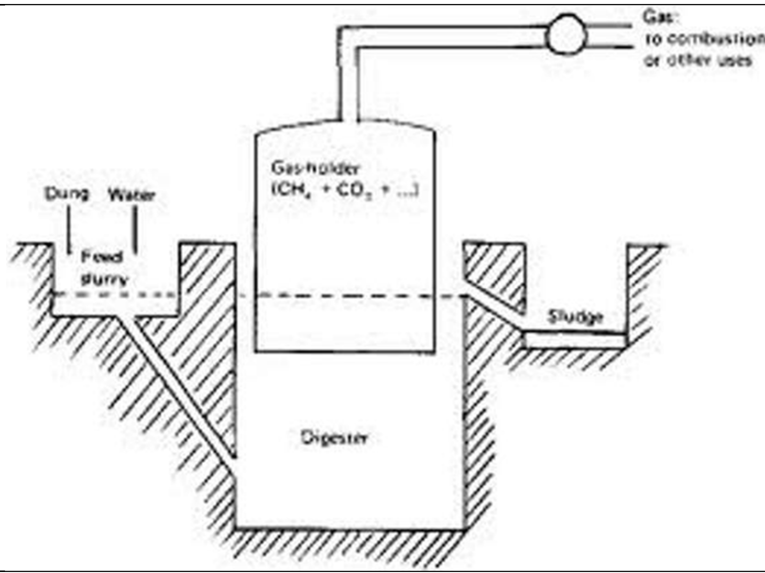
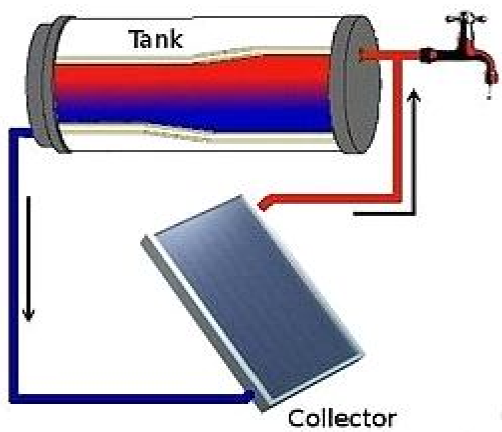
<tr><td>(D)</td><td>

Pump Performance Curve</td><td></td></tr>
<tr><td>(E)</td><td>Solar Cooker
The basic purpose of a solar box cooker is to heat things up - cook food, purify water, and sterilize instruments - to mention a few.
A solar box cooks because the interior of the box is heated by the energy of the sun. Sunlight, both direct and reflected, enters the solar box through the glass or plastic top. It turns to heat energy when it is absorbed by the dark absorber plate and cooking pots. This heat input causes the temperature inside of the solar box cooker to rise until the heat loss of the cooker is equal to the solar heat gain. Temperatures sufficient for cooking food and pasteurizing water are easily achieved.
Given two boxes that have the same heat retention capabilities, the one that has more gain, from stronger sunlight or additional sunlight via a reflector, will be hotter inside.
Given two boxes that have equal heat gain, the one that has more heat retention capabilities - better insulated walls, bottom, and top - will reach a higher interior temperature.

Principle of a solar oven</td><td>4</td></tr>
</table>

(F)	 	4
6 (a)	 	4
(b)	Rate of heat loss per unit area =[(T1-T2)]/[(1/h1)+(Δx/k)+(1/h2)] =[(100-20)]/[(1/ 2850)+(0.012/50)+(1/10)] =[80]/[1.00352] =797 W/m^2	4
(c)	In alternating current (AC, also ac), the flow of electric charge periodically reverses direction. In direct current (DC, also dc), the flow of electric charge is only in one direction. Direct current (DC) is the unidirectional flow of electric charge. Direct current is produced by sources such as batteries, thermocouples, solar cells, and commutator-type electric machines of the dynamo type. Electricity tariff are the charges collected by electricity distribution company from its consumer according type of connection given. The tariffs are different for different costumers.	2+2
(e)	The Government of India set up Bureau of Energy Efficiency (BEE) on 1st March 2002 under the provisions of the Energy Conservation Act, 2001. The	1+3

	mission of the Bureau of Energy Efficiency is to assist in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing energy intensity of the Indian economy. Role of BEE • Develop minimum energy performance standards and labeling design for equipment and appliances • Develop specific Energy Conservation Building Codes • Activities focusing on designated consumers • Develop specific energy consumption norms • Certify Energy Managers and Energy Auditors • Accredit Energy Auditors • Define the manner and periodicity of mandatory energy audits • Develop reporting formats on energy consumption and action taken on the recommendations of the energy auditors	
(f)	During operation with most liquids and some gases a dirt film gradually builds up on the heat-transfer surface. The deposit is referred to as scaling. Heat exchangers are made up with metals. When fluid flow through heat exchanger due to heating and cooling dirt present in fluid get deposited on heat transfer surface which increase resistance to heat transfer. Some solid material dissolved in liquid gets precipitated and get deposited on surface.	4