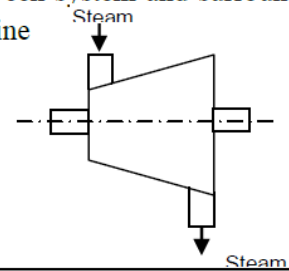
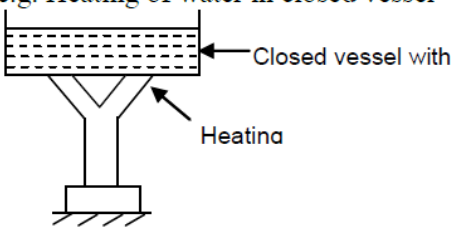
SUMMER – 19 EXAMINATION

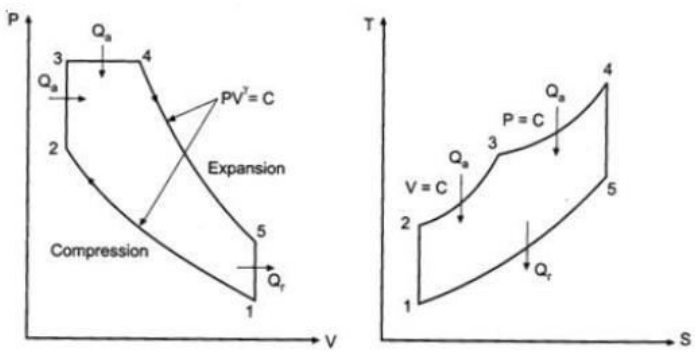
Subject Name: Heat Power Engineering **Model Answer** Subject Code: 22441

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.

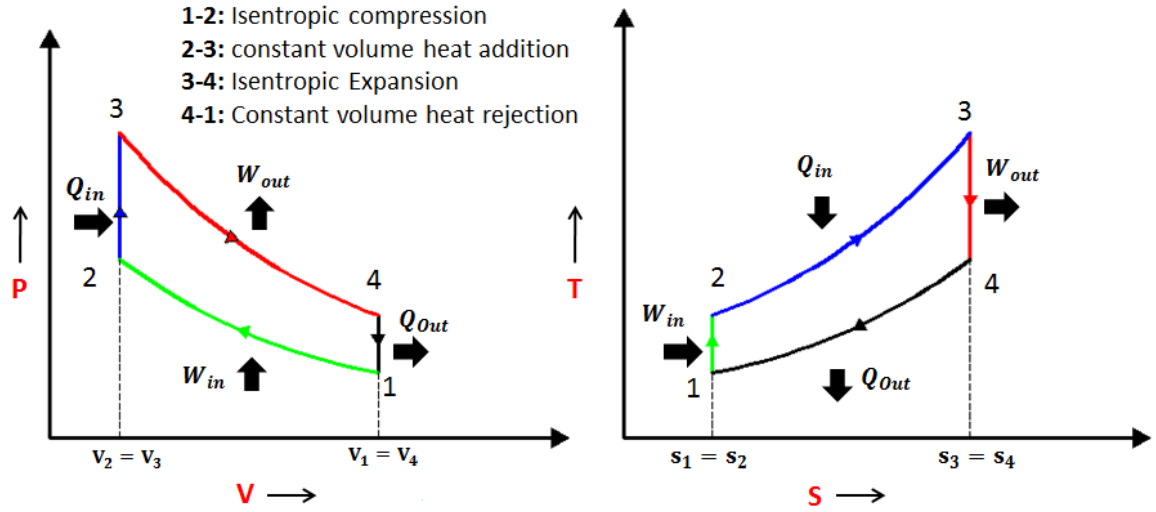
	Sub Q. N.	Answer	Marking Scheme
1		**Attempt any FIVE**	
	(a)	**Differentiate between open and close system**	
	Ans.	Open system :This is a system in which both mass and energy crosses the system boundary OR transfer of mass and energy between system and surrounding e.g. steam turbine  Closed system: In this system, there no mass transfer taking place between system and surrounding, only the energy crosses boundary e.g. Heating of water in closed vessel 	**01 Mark each**
	(b)	**Write equation for polytropic process**	
	Ans.	**i)change in internal energy(du):** du= m Cv (T_2-T_1) **ii)work done dw:** dw= P_1V_2-P_2V_2 / n-1	**01Mark** **01Mark**
	(c)	**State four properties of liquid fuel (each1/2 mark)**	
	Ans.	1. High calorific value 2. Moderate ignition temperature 3. Low moisture content 4. Low NOx combustible matter	**02 Marks**

		5. Moderate velocity of combustion 6. Products of combustion not harmful 7. Low cost 8. Easy to transport 9. Combustion should be controllable 10. No spontaneous combustion 11. Low storage cost 12. Should burn in air with efficiency.	
	(d)	**Define**	
	Ans.	**i)Dryness fraction:** Dryness fraction is defined ratio of the mass of the dry steam present in the total mass of steam. Or *Dryness fraction is ratio of the mass of actual dry steam to the mass of wet steam.* Therefore, x = ms/ ms + mw Where ms and mw are the masses of steam and water in the mixture of (ms + mw). **ii) Degree of superheat:** It i difference between the temperature of Superheated Steam and the saturation temperature correspondingly to given pressure is said to be Degree of Superheat.	**01Mark** **01Mark**
	(e)	**State two advantages of multistage compression**	
	Ans.	1.Saving in work is obtained 2.There is little chance of lubrication trouble as the maximum temperature is reduced. 3.it improves the volumetric efficiency. 4.the leakage loss is reduced considerably. 5. it provide more uniform torque and thus smaller size flywheel is required. 6.lighrter cylinders.	**02 (1 mark each)**
	(f)	**Define renewable energy. Give two examples.**	
	Ans.	Renewable energy : Energy generated by using wind, tides, solar,geothermal heat, and biomass including farm and animal waste as well as human excreta is known as non-conventional energy. All these sources are renewable or in exhaustible and do not cause environmental pollution. More over they do not require heavy expenditure. The example of Renewable energy sources 1. Wind power 2. Biomass 3. Solar applications of energy 4. Hydraulic power 5. Fuel cells 6. Bio fuels	**01Mark** **01Mark**
	(g)	**State two limitations of solar energy**	
	Ans.	1. Uses a Lot of Space 2.High initial capital costs 3. Problem of efficiency (low) 4.Weather dependent 5.Solar energy storage is expensive	**02 Marks**
2		**Attempt any THREE**	
	(a)	**Classify steam turbine on the basis of**	
	Ans.	i) Principle of action: a) Impulse turbine b) Reaction turbine c) Impulse reaction turbine ii) Direction of steam flow: a) axial flow turbine b) Radial flow turbine c) Tangential flow turbine	**01Mark** **01Mark**

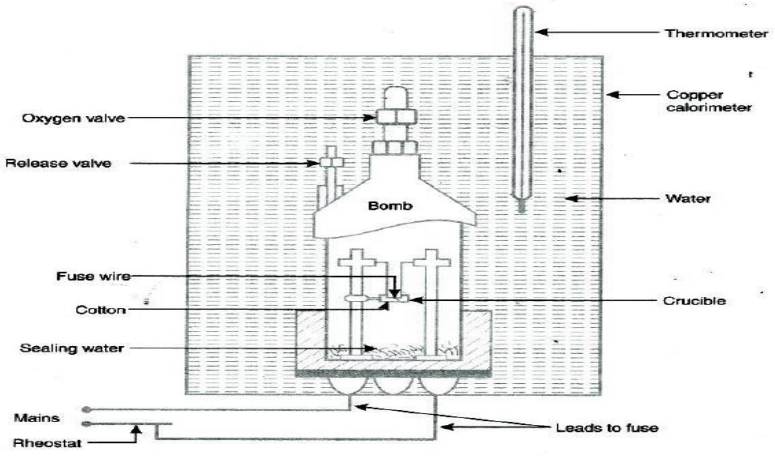
		iii)method of governing: a)Throttle governing turbine b) Nozzle control governing turbine c) By pass governing turbine d) combination of all iv) Steam pressure: a)High pressure turbine b) Low pressure turbine c) Medium pressure turbine	**01Mark** **01Mark**
	(b)	**Draw dual cycle on P V and T S diagram and write the processes involved in it.**	
	Ans.	**Dual Combustion cycle:**  1-2 Isentropic compression of air 2-3 the combustion of fuel at constant volume. 3-4 the combustion of fuel at constant pressure 4-5 Isentropic expansion during which work is done by the system. 5-1 Heat rejection at constant volume.	**02 Marks For diagram** **02 Marks for process**
	(c)	**Classify the steam boiler on the basis of**	
	Ans.	**i) Content in the tubes**: a) Fire tube boiler b) Water tube boiler ii)Circulation of water and steam: a) Natural circulation boiler b) Forced circulation boiler iii)According to boiler use: a) Stationary boiler b) Mobile boiler iv)according to axis of shell a) Horizontal boiler b) Vertical boiler c) Inclined boiler	**01 Mark** **01 Mark** **01 Mark** **01 Mark**
	(d)	**Compare rotary and reciprocating air compressor on the basis of the following points:**	

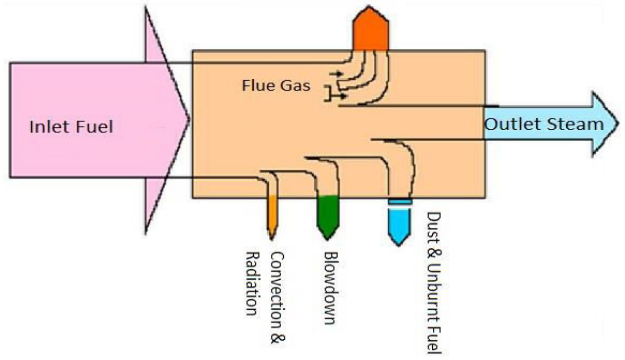
	Ans.	**Points**	**Rotary air compressor**	**Reciprocating air compressor**
		i) Suitable at low and high discharge	Discharge pressure of air is low. The pressure	Discharge Pressure of air is high. The pressure

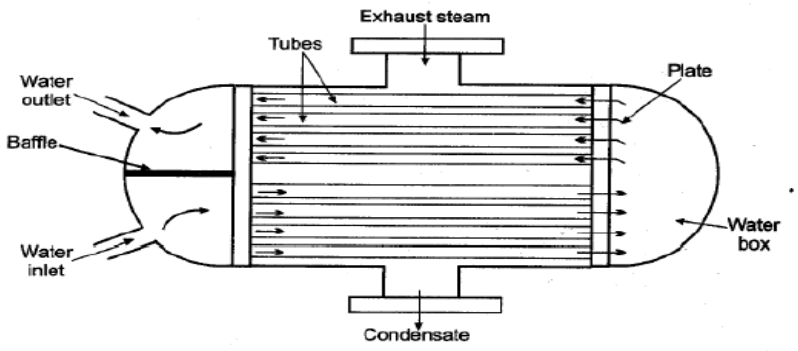
01 Mark

			ratio per stage will be in the order of 3 to 5. For low and medium pressures. For large volumes.	ratio per stage will be in the order of 4 to 7. For medium and high pressure atio. For low and medium gas volume.	
		ii) requirement of receiver	No need	required	**01 Mark**
		iii) balancing problem	Rotary parts of machine, thus it has less vibrational problems. The machine parts are fairly balanced.	Due to reciprocating section, greater vibrational problem, the parts of machine are poorly balanced.	**01 Mark**
		iv) lubricant requirements	Simple lubrication system.	Complicated lubrication system.	**01Mark**
3		**Attempt any THREE**			
	(a)	**Draw P V and T S diagram of Otto cycle and write its equation for thermal efficiency with its significance.**			
	Ans.	**P V and T S diagram of Otto cycle**  **P-V and T-S Diagram of Otto Cycle** **Thermal efficiency** $\eta_{th} = \frac{\text{Work Done}}{\text{Heat Supplied}}$ $\eta_{th} = 1 - \frac{1}{r^{(\gamma - 1)}}$ **Compression ratio = r**			**Diagram 02 Marks** **Equation 02 Marks**

	(b)	**A coal has following composition by mass: 82% H_2 =5%, S=1.5%,O_2=2.4,N2=1% and remaining is ash. Find HCV and LCV of fuel.**	
	Ans.	Given Data: **(consider Carbon mass 82%)** Carbon C = 82% = 0.82, Hydrogen = H_2 = 5% = 0.05 Oxygen = O_2 = 2.4% = 0.024 Nitrogen = N = 1% = 0.01 Sulphur = S =1.5 % = 0.015 Dulong's formula H.C.V. of coal = 33800 C + 144500 (H_2 - O_2/8) + 9300 S KJ / Kg =33800 x 0.82 + 144500 (0.05 - 0.024/8) + 9300 x 0.015 =27716+6791.5+139.5 = 34647 KJ / Kg L.C.V. of coal = H.C.V.- 9H_2 x 2442 KJ / Kg = 34647 - (9 x 0.05) x 2442 = 33548.1 KJ / Kg	**02 Marks** **02 Marks**
	(c)	**Suggest energy conservation techniques to be used in automobile workshop. Any four points**	
	Ans.	1.Take advantage of the used-oil exemption rule by installing an oil-drip heater for your facility. you can burn your used oil and generate heat at your facility reducing the disposal costs associated with oil . 2.Keep interior doors closed that separate bay areas from the rest of the building. 3. Install an exhaust fan system with hose connections to tailpipes to remove exhaust fumes without displacing the heated or cooled air in the service area. 4.Proper maintenance of equipment, including vehicle repair equipment, heating, cooling and office equipment, is essential for obtaining maximum energy efficiency. 5. Check and replace filters often and follow manufacturer-recommended maintenance schedules. ‰ 6. Turn off computers and equipment when not in use and at the end of the day. 7. Buy energy-efficient machines. 8. Landscaping around a building can provide shade in the summer and protection against wind in the winter lowering heating and cooling costs and saving money. 9.Turn off lights when an area (break room, bathroom or storage closet) is unoccupied. 10. Install timing devices on lights, vending machines and copiers to power down the machines during times of low use or purchase equipment with this option. 11. Replace incandescent exit lights with three to seven watt LED exit lights. These lights last longer (up to 25 years) and reduce maintenance costs.	**1 x4 Marks**
	(d)	**Two kg of gas at 50^o C is heated at constant volume until pressure is doubled. Determine i) final temperature ii) change in internal energy**	
	Ans.	**Given data:** Mass of gas m=2 kg Temperature of gas T_1 = 50+273= 323 K Initial pressure P_1 Final pressure P_2 = 2 P_1 **i) final temperature** T_2 For constant volume process V1= V2 $P_1/T_1 = P_2/T_2$	**02 Marks**

		$P_1/323 = 2\ P_1/T_2$ $T_2 = 646\ K = 373\ ^oC$ **ii) change in internal energy du** $du = mCv\ (T_2 - T_1)$ $= 2 \times 0.718\ (646 - 323)$ $= 463.82\ KJ$	**02 Marks**
4		**Attempt any THREE of the following**	
	(a)	**Explain the following terms with example**	
		1) Conduction- It is the mode of heat transfer from one part of substance to another part of same substance or one substance to another without displacement of molecules or due to the vibrations of molecules. **Example-**Heat transfer in metal rod. **2) Convection:** It is the mode of heat transfer from one part of substance to another part of same substance or one substance to another with displacement of molecules or due to the fluid flowing. **Example:** Heat flow from boiler shell to water. **3) Radiation:** It is the transfer of heat through space or matter. For Radiation there is no need of medium as like convection and conduction. It passes through vacuum in the form of electromagnetic waves. **Example:** The heat energy receives from sun to the earth surface.	**1.5 Marks** **1Mark** **1.5 Marks**
	(b)	**Describe with neat sketch of working of bomb calorimeter**	
		working of bomb calorimeter:  **Fig. Bomb calorimeter** The calorimeter is made of austenitic steel which provides considerable resistant to corrosion and enables it to withstand high pressure. In the calorimeter use of a strong cylindrical bomb in which combustion occurs. The bomb has two values at the top. One supplies oxygen to the bomb and other releases the exhaust gases. A crucible in which a weighed quantity of fuel sample is burnt is arranged between the two electrodes as shown in fig. The calorimeter is fitted with water jacket which surrounds the bomb To reduce the losses due to radiation calorimeter is further provided with a jacket of water and air. A stirrer for keeping the temperature of water uniform and a thermometer the	**Sketch 02 Marks** **Explanation 02 Marks**

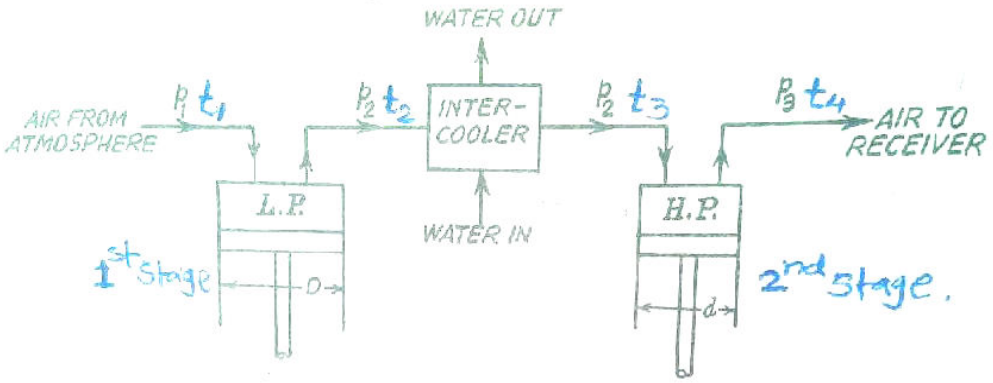
		temperature up to accuracy of 0.0010 C is fitted through the lid of the calorimeter. The heat released by the fuel on combustion is absorbed by the surrounding water and the calorimeter. From the above data the calorific value of the fuel can be found.	
	c)	**Sketch energy flow diagram for steam boiler**	
	Ans:	 **Fig. Energy flow diagram of Steam Boiler**	**Sketch 04 Marks**
	d)	**State the factor governing the selection of cogeneration system. write advantages of cogeneration.**	
	Ans:	**Factor governing the selection of cogeneration system:** 1) electrical load matching 2) thermal load matching 3) Electrical load matching 4) Thermal load matching 5)Thermal to electrical energy ratio 6) Quality of required thermal energy 7) Fuel availability 8) Installation and available space 9) Operational costs 10) Pollution concern **Advantages of Cogeneration:** 1) Co-generation can meet both power & heat needs. 2) Less costly. 3) Very high efficiency. 4) Reduction in emission of pollutants due to reduced fuel consumption.	**02 Marks** **02 Marks**
	(e)	**State the various factors affecting volumetric efficiency of air compressor**	
	Ans:	**Factors affecting volumetric efficiency of reciprocating air compressor:** 1) Clearance Volume 2) Restricted passage and leakage at inlet valves 3) Speed of rotation 4) Piston ring leakages 5) If fresh air comes in contact with hot wall, it get expanded, which decreases the charge taken in therefore volumetric efficiency decreases.	**04 Marks**
5		**Attempt any Two of the following**	
	a)	**Describe ultimate analysis and proximate analysis of solid fuel**	
		Ultimate Analysis: Ultimate analysis is complete breakdown of coal into Chemical constituents. This analysis is important for large scale trials. It serves the basis For calculation of the amount of air required for complete combustion of 1kg of fuel. It gives percentage content on mass basis of carbon, hydrogen, oxygen,	

		Sulphur and ash. We are able to calculate the Calorific value of coal. In ultimate analysis a complete breakdown of coal into its chemical constituents is carried out by chemical process. This analysis is important for large scale trials i.e. boiler trial. This analysis useful for calculation of amount of air required for complete combustion of 1 Kg. of coal. This analysis gives percentage of carbon, hydrogen, oxygen, sulphur and ash on mass basis their sum is taken as equal to 100%. In this analysis moisture is consider as separate item. This analysis is also used to determine calorific value of the coal. **Proximate Analysis:** Proximate analysis is complete breakdown of coal into physical constituents without knowledge of analytical chemistry. This analysis made By means of a chemical balance &temperature control Furnace. The component in The analysis is fixed carbon volatile matter, moisture& ash. This is used to calculate The heating value of coal.In this analysis separation of coal into its physical components. This analysis made by means of chemical balance and temperature controlled furnace. In this analysis sample is heated into furnace. The components in analysis are fixed, carbon, volatile matter, moisture and ash. These components are expressed in percentage on mass basis and their sum is taken as 100% sulphur is determined separately. This analysis also used to determine heating value of the coal.	**03 Marks** **03 Marks**
	b)	**Describe with neat sketch the construction and working of surface condenser**	
	Ans:	 **Fig. Two pass down flow surface condenser** **Construction-** It consists of horizontal cast iron cylindrical vessel pack with tubes, through which the cooling water flows. The ends of the condenser are cut off by vertical perforated type plates into which water tubes are fixed. This is done in such a manner that the leakage of water in to the centre condensing space is prevented. **Working** :The water tubes pass horizontally through the main condensing space for the steam. The steam enters at the top & is forced to flow downwards over the tubes due to the suction of the extraction pump at the bottom. The cooling water flows in one direction through lower half of the tubes & return in opposite direction through the upper half as shown in figure. The condensate does not mix with cooling water which is used for cooling steam & convert into water; therefore whole condensate can be the reused in the boiler. It is used to increase the turbine output by maintaining backpressure on exhaust side of steam engine or turbine & the secondary function of condenser is to supply pure and hot feed water to boiler.	**Sketch 02 Marks** **Construction 02 Marks** **Working 02 Marks**

	c)	**Describe government policy for harnessing the potential power of renewable energy sources**	
	Ans:	**1) Promote hybridization of solar and wind energy and build ancillary markets:**The synergy in a hybrid wind and solar plant will help reduce variability in power generation. Hybrid projects would also have much higher capacity utilization factors, thus practically eliminating the intermittency challenge. Such projects have the additional benefit of reducing the costs associated with the sharing of transmission lines. **2) Build enhanced evacuation infrastructure:** We need greater investment in high-voltage transmission lines to transport bulk energy over vast distances quickly and efficiently from power-rich to power-scarce states. **3) Invest in digitalization:** There is huge potential for advanced software solutions that can optimize grid-level operations besides impacting consumer behaviour. The creation of demand response programmes. **4) Develop battery storage solutions:** As battery storage costs continue to fall precipitously, they will become an increasingly important tool for managing the fluctuating pattern of renewable energy generation. **5) Turnaround the distribution companies:** Nearly a quarter of electricity generated is lost in transmission because India's distribution companies (known here as discoms) use outdated infrastructure, resulting in line faults and leakages, as well as undersized and over-utilized transformers.	**06 Marks**
6		**Attempt any Two of the following**	
	a)	**Calculte enthalpy of 1 kg of steam at a pressure of 7bar and dryness fraction 0.8. How much heat would be required to generate 2 kg of this steam from water at 30 ^{o} C? Take** Cpw =4.187KJ/Kg.K	
	Ans:	**Given Data**: Pressure of steam P= 7 Bar , Dryness Fraction x= 0.8 , Cpw =4.187KJ/Kg.K (at P= 7bar given values) h_f= 697.20 KJ/Kg h_{fg} = 2066.3. KJ/Kg i) Enthaply of one kg of wet steam at 7 bar h= h_f + x h_{fg} h= 697.20 + 0.8 x 2066.3 **h=2350.25 KJ/Kg** ii) Enthalpy of water at 30º C hwater = m x Cpw x T = 2 x 4.187 x (30+273) = **1268.66 KJ/kg** iii) Heat required to generate one kg of steam = h – hwater =2350.25 -1268.66**= 1081.59 KJ/kg** iv) Heat required to generate 2 kg of steam = 2 x 1081.59 **= 2163.18 KJ /kg**	**02 Marks** **02 Marks** **01 Mark** **01 Mark**

b) Describe with neat sketch working of air compressor used in automobile workshops. State its two advantages

Ans:



Sketch 02 Marks

As shown in ig. Shows two stages reciprocating air compressor with water cooled and intercooler

First of all fresh air is sucked from atmosphere in low pressure (L.P) cylinder during its suction stroke at inlet pressure P1 and temp T1.The air after compression in L,P cylinder (I st stage) from 1 to 2 is delivered to intercooler at pressure P2 and temp T2.Now air is cooled in intercooler from 2 to3 at constant pressure P2 and from temp T2 to T3.After that air is sucked in high pressure (H.P) cylinder during its suction stroke. Finally air after further compression in H.P. cylinder (ie second stage) from 3 to 4 is delivered by the compressor at pressure P3 & Temp T4.

Working 02 Marks

Advantages :

1) Less power is required to drive the compressor.
2) Higher volumetric efficiency

02 Marks

c) State two strength and two limitations of following power plants.

Ans:

Power plant	Strength	limitations
Solar power plant	1) They do not pollute the atmosphere. 2) Such type of plants suitable in rural areas where for installation large space is available. 3) Clean and cheap energy source. 4) Easily available in nature	1)installation cost is high 2) For night application storage facility is required.
Geo-thermal power plant	1) Renewable source of energy. 2) It is pollution free; No, Co2 emission. 3) Clean and cheap energy source. 4) Easily available in nature.	1) Selection is very important and difficult task. 2) Advanced technology required to construct and operate plant.

02 Marks

02 Marks

		Biomass power plant	1) Raw material used as cow dung is easily available in villages, rural area at free of cost. 2) Easy to operate and having less maintenance. 3) No additional Co2 emission to environment. 4) Digested matter used as fertilizer.	1)Effectively implemented only where open space is available 2) For producing gas it takes more time. 3) Initial investment is required for construction of well.	**02 Marks**

(Strength 1 Mark and Limitation 1 Mark each)

THE END