WINTER– 17 EXAMINATION

Model Answer

Subject: HEAT POWER ENGINEERING **Subject Code: 17407**

Important Instructions to examiners:

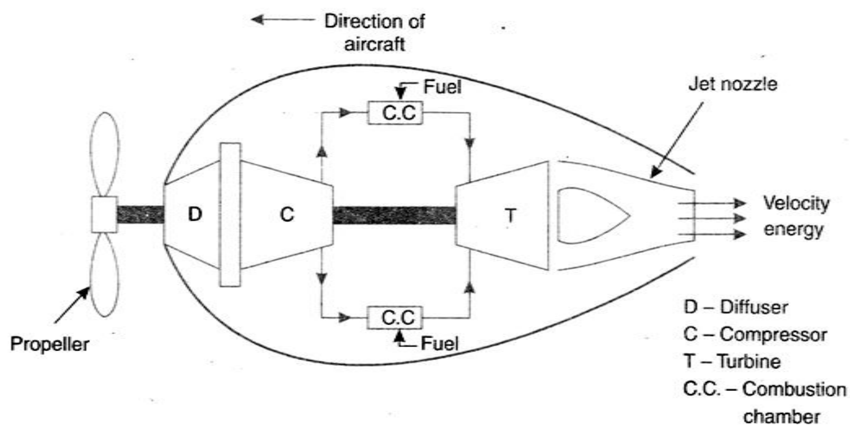
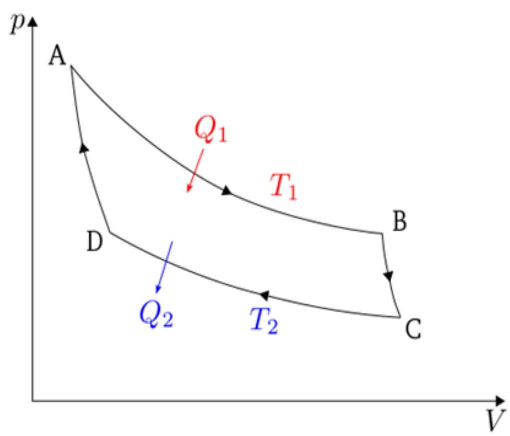
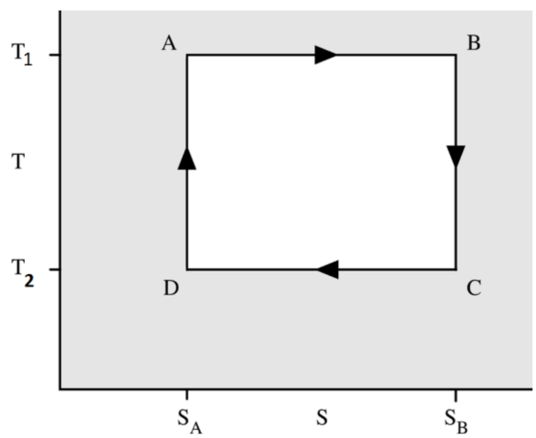
1) The answers should be examined by key words and not as word-to-word as given in themodel answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may tryto assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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 anyequivalent 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 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 SIX of the following**	12
	(a)	**List different types of thermodynamic processes for ideal gases.**	02
	ANS:	**Different types of thermodynamic processes :** *(Any Four)* i) Isobaric Process (Constant Pressure Process) ii) Isochoric Process (Constant Volume Process) iii) Isothermal Process (Constant temperature Process) iv) Reversible Adiabatic Process or Isentropic Process v) Polytropic Process	02
	(b)	**Define dryness fraction and degree of superheat**	02
	ANS:	**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, $$x = \frac{m_s}{m_s + m_w}$$ Where m_s and m_w are the masses of steam and water in the mixture of ($m_s + m_w$). **Degree of superheat:** It is difference between the temperature of Superheated Steam and the saturation temperature correspondingly to given pressure is said to be Degree of Superheat.	01 01

	(c)	**State necessity of multi-staging in air compressor.**	**02**
	ANS:	**Necessity of multistaging** – *(Any Four)* It has been experienced that if we employ single stage compression for producing high pressure air (say 8 to 10 bar) it suffers the following draw backs 1. The size of cylinder will be too large. 2. Work required to drive the compressor is more 3. Due to high pressure loss of air due to leakage is more. 4. Sometimes, the temperature of air, at the end of compression is too high. It may be heat up the cylinder head or burn the lubricating oil. 5. Volumetric efficiency of compressor is less In order to overcome the above mentioned difficulties two or more cylinders are provided in series with inter-cooling arrangement between them. Such an arrangement is known as multistage compression with inter-cooling.	**02**
	(d)	**Define Free Air Delivered.(FAD)**	**02**
	ANS:	Answer: **Free Air Delivered (FAD):** It is the actual volume of air delivered by the compressor when reduced to NTP.	**02**
	(e)	**List any four applications of gas turbine.**	**02**
	ANS:	**Applications of gas turbine:** *(Any four)* 1. Supercharging of I.C. engine 2. For locomotive Propulsion 3. Ship Propulsion 4. Industrial application 5. Air craft engine 6. Electric power generation 7. Turbo-jet engine 8. Turbo-prop engine 9. Ram-jet engine 10. Pulse-jet engine	**For any four ½ mark each**
	(f)	**State the classification of sources of energy.**	**02**
	ANS:	**Conventional sources of energy:** *(Any two)* i) Petrol ii) Diesel iii) Kerosene iv) Oil **Non-conventional sources of energy:** *(Any two)* i) Solar energy ii) Wind energy iii) Geothermal energy iv) Tidal energy v)Biomass	**01** **01**

	(g)	**Define H.C.V. and L.C.V. of fuel.**	**02**
	ANS:	**H.C.V. of Fuel:** Higher calorific value of fuel is defined as amount of heat energy obtain by the complete combustion of 1kg of fuel, when the products of its combustion are cooled down to the temperature of supplied air. Unit is (KJ/kg) **L.C.V. of Fuel:** When heat absorbed or carried away by the product of combustion is not recovered & steam is formed during combustion is not condensed. Then the amount of heat obtain per kg of fuel is known as lower calorific value of fuel. Unit is (KJ/kg)	**01** **01**
	(h)	**State any four requirements of good fuel.**	**02**
	ANS:	**Requirements of good fuel** 1. High calorific value 2. Moderate ignition temperature 3. Low moisture content 4. Low NO_x combustible matter 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.	**For any four 02 marks**
1	**(B)**	**Attempt any TWO of the following**	**08**
	(a)	**Explain the different modes of heat transfer. List any four applications of heat transfer in automobiles.**	**04**
	ANS:	**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. **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. **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. **Applications of heat transfer:** 1) Fins provided on motor cycle engine. 2) Cooling jackets provided in cylinder blocks 3) Radiator 4) Heat carried away by exhaust gases 5) Heat transfer from sunrays into the cabin/car **6)** HVAC system etc.	**02** **2marks for any four**

	(b)	**A steam engine obtains steam from a boiler at a pressure of 15 bar and 0.98 dry. It was observed that the steam lost 21 kJ of heat per kg as it flows through the pipeline,pressure remains constant. Calculate dryness fraction of the steam , at the end of pipeline(take h_f = 844.6 KJ/kg and h_{fg} = 1945.3KJ/kg at 15 bar pressure)**	**04**
	ANS:	**Answer:** **Given data:** $P_1 = 15$ bar $= P_2$ $x_1 = 0.98$ Heat Loss = 21 KJ /kg Properties of steam At 15 bar $h_f = 844.6$ KJ /kg $h_{fg} = 1945.3$ KJ /kg Enthalpy of stream at boiler end is $h_1 = h_{f1} + x_1 . h_{fg1}$ $= 844.6 + (0.98 \times 1945.3)$ $= 2750.994$ KJ /kg As steam losses 21 KJ /kg of heat, while passing upto engine end , therefore Enthalpy of steam at engine end is, $h_2 = h_1 -$ Heat loss $= 2750.994 - 21$ $= 2729.994$ KJ /kg We Know $h_2 = h_{f2} + x_2 . h_{fg2}$ $\therefore 2729.994 = 844.6 + (x_2 \times 1945.3)$ $\therefore$ **x_2 = 0.9692** ……………………**ANS.**	**01** **01** **02**
	(c)	**Explain working principle of turboprop engine with neat sketch.**	**04**
	ANS:	**Turboprop Engine:** Figure shows a turboprop system employed in aircrafts. Here the expansion of gases takes place partly in turbine 80% and partly 20% in the nozzle. The power developed by the turbine is consumed in running the compressor and the propeller. The propeller and jet produced by the nozzle give forward motion to the aircraft. The turboprop entails the advantages of turbojet (i.e. low specific weight and simplicity in design) and propeller (i.e. high power for takeoff and high propulsion efficiency at speeds below 600km/h). The overall efficiency of the turbo prop is improved by providing the diffuser before the compressor as shown. The pressure rise takes place in the diffuser. This pressure rise take due to conversion of kinetic energy of the incoming air (equal to aircraft	**02**

		velocity) into pressure energy by diffuser. This type of compression is known as "ram effect". 	02
2		**Attempt any FOUR of the following**	**16**
	(a)	**Represent the Carnot and Dual combustion cycle on P-V and T-S diagram and also write equation for air standard efficiency of the same.**	**04**
		 	01
		1) A-B & C- D are Two Reversible Isothermal Processes 2) B-C & D-A are Two ReversibleIsentropic Processes **Air standard efficiency of Carnot Cycle:-** $\eta = (T1-T2) / T1$ Where, T1= temperature of source T2= temperature of sink	01

Dual Combustion cycle:

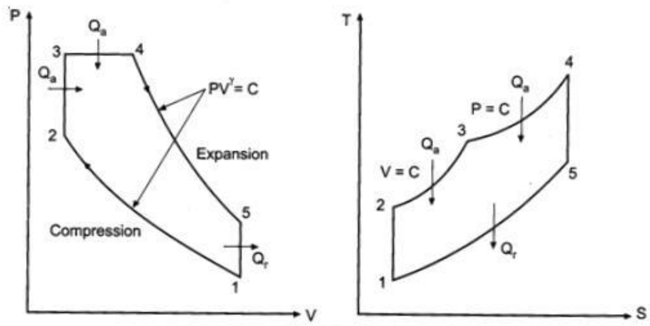


Fig. : Dual cycle

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Air Standard efficiency of Dual cycle

$$\eta_{Dual} = 1 - \frac{1}{(r)^{\gamma - 1}}\left[\frac{(\beta.\rho^{\gamma} - 1)}{(\beta - 1) + \beta\gamma(\rho - 1)}\right]$$

Where r = compression ratio = V_1/V_2

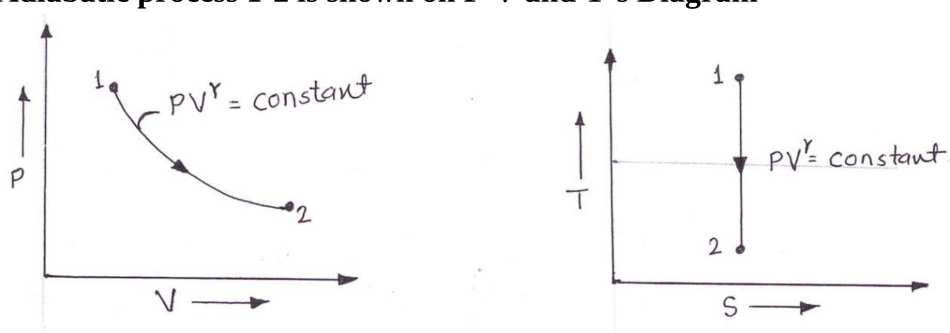
P = cut-off ratio= V_4/V_3 01

β = pressure of expansion ratio= P_3/P_2

(b) **Derive an expression for the work done in the adiabatic process.** **04**

ANS: **Work done during adiabatic process:**

Adiabatic process 1-2 is shown on P-V and T-s Diagram



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Work done during thermodynamic process is given as

$W_{1\text{-}2} = \int_1^2 Pdv$ ……………………………………..(1) 01

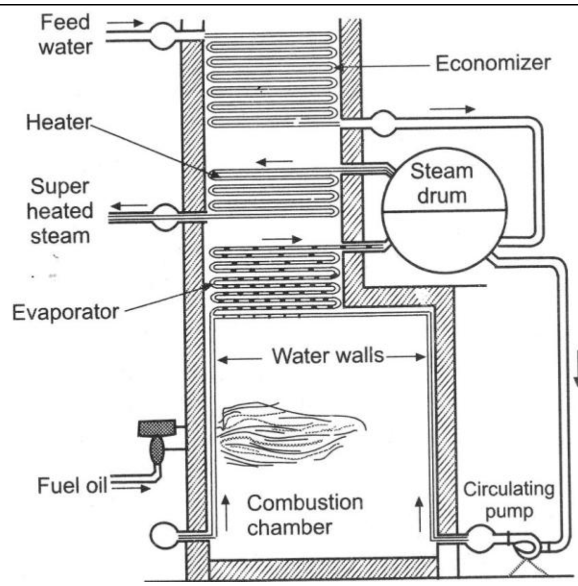
But

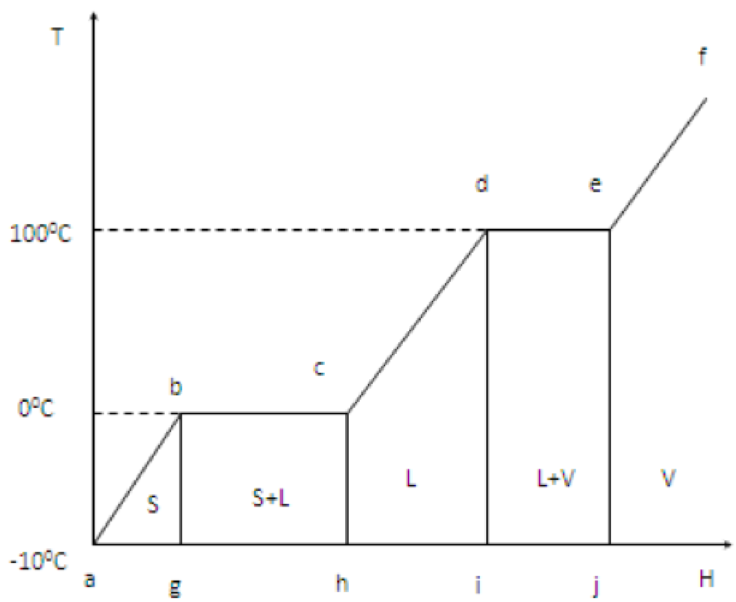
$PV^{\gamma} = P_1 V_1^{\gamma}$

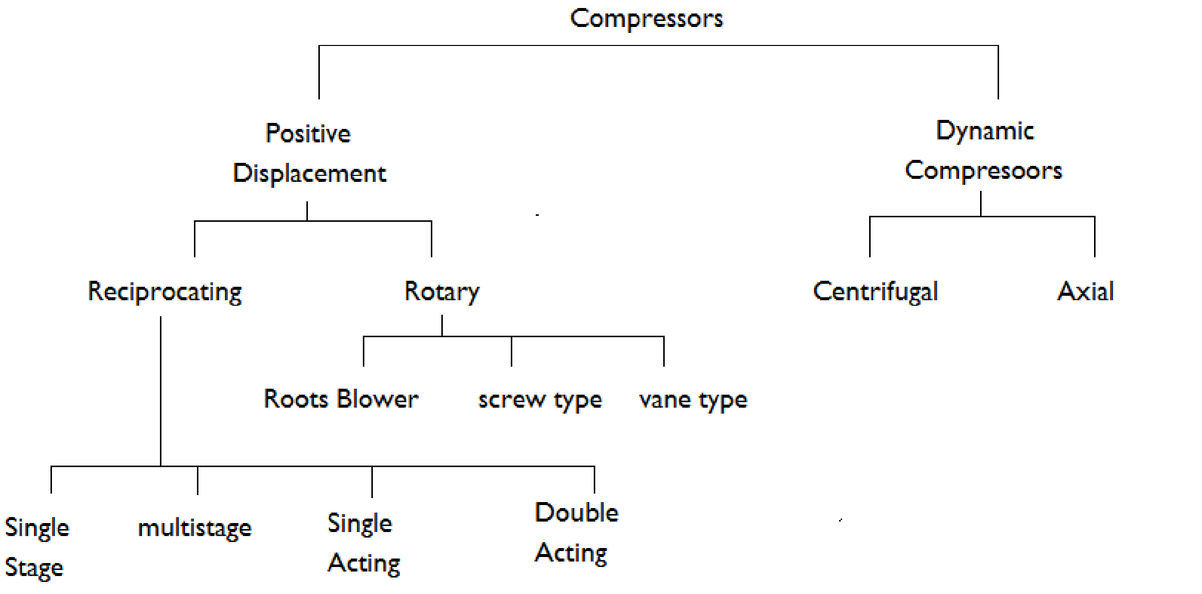
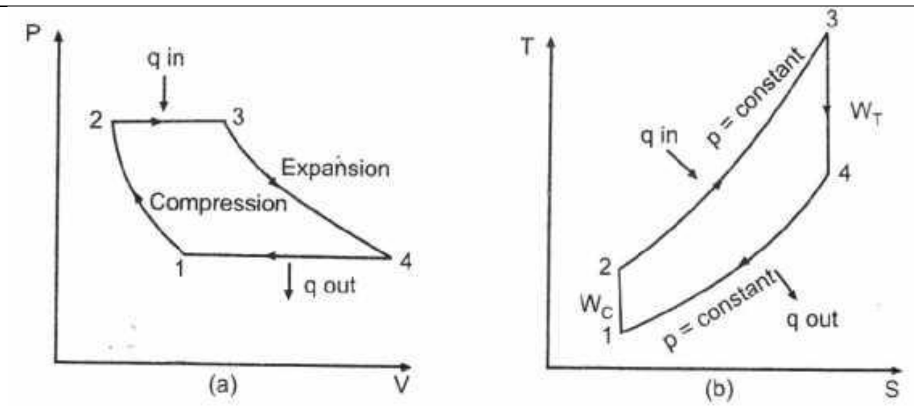
$\therefore P = \frac{P1\, V_1^{\gamma}}{V^{\gamma}}$

Put this value in equation (1)

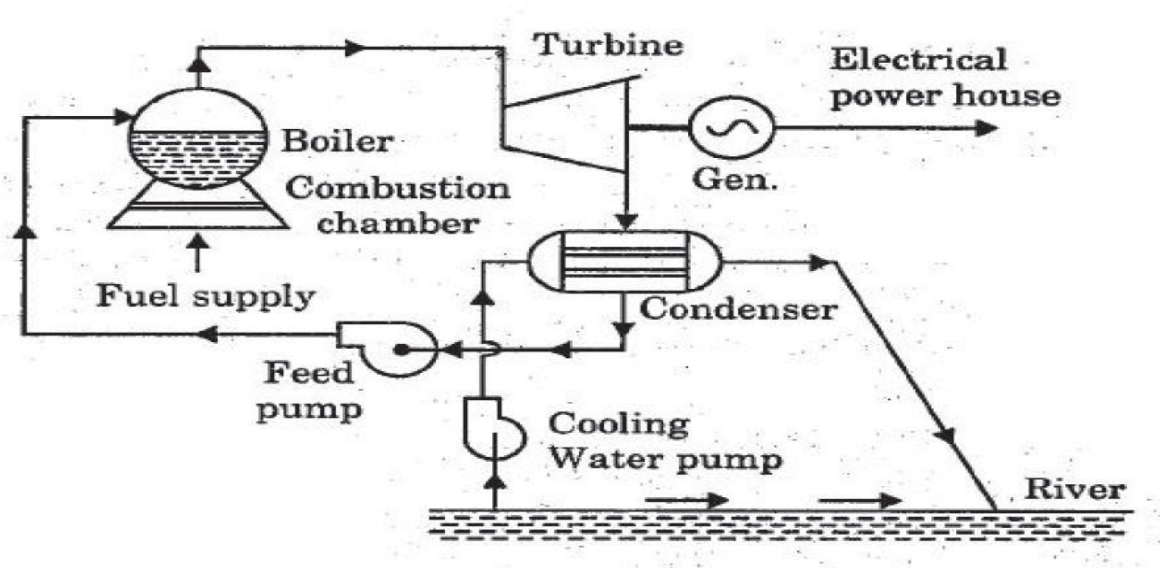
$W_{1\text{-}2} = \int_1^2 \frac{P1\, V_1^{\gamma}}{V^{\gamma}} dv$

		$= P_1 V_1^{\gamma} \int_1^2 V^{-\gamma} dv$ $= P_1 V_1^{\gamma} [\frac{V^{-\gamma+1}}{-\gamma+1}]_1^2$ $= P_1 V_1^{\gamma} [\frac{V^{1-\gamma}}{1-\gamma}]_1^2$ $= \frac{P1\, V_1^{\gamma}}{1-\gamma} [V_2^{1-\gamma} - V_1^{1-\gamma}]$ $= \frac{P1\, V_1^{\gamma} .\, V_2^{1-\gamma} - P1\, V_1^{\gamma} .\, V_1^{1-\gamma}}{1-\gamma}$ $= \frac{P2\, V_2^{\gamma} .\, V_2^{1-\gamma} - P1\, V_1^{\gamma} .\, V_1^{1-\gamma}}{1-\gamma}$ ……………(as $P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$) $= \frac{P2\, V_2^{\gamma+1-\gamma} - P1\, V_1^{\gamma+1-\gamma}}{1-\gamma}$ $= \frac{P2\, V_2 - P1\, V_1}{1-\gamma}$ $W_{1-2} = \frac{P1\, V_1 - P2 V_2}{\gamma-1} = \frac{mR\ (T1-T2)}{\gamma-1}$ ……………..for expansion process $W_{1-2} = \frac{P2\, V_2 - P1\, V_1}{\gamma-1} = \frac{mR\ (T2-T1)}{\gamma-1}$…………...….for compression proces.	01 01
	(c)	**Draw neat & labeled sketch of La-mount boiler.**	**04**
	ANS:	 **Figure La-mont Boiler**	**04**
	(d)	**State and explain different phases in formation of steam.**	**04**
	ANS:	**Different phases of Formation of steam-** Consider formation of steam from ice at -100 C **Solid phase-** When the heat is added in ice which is at -100 C, the temperature of ice	

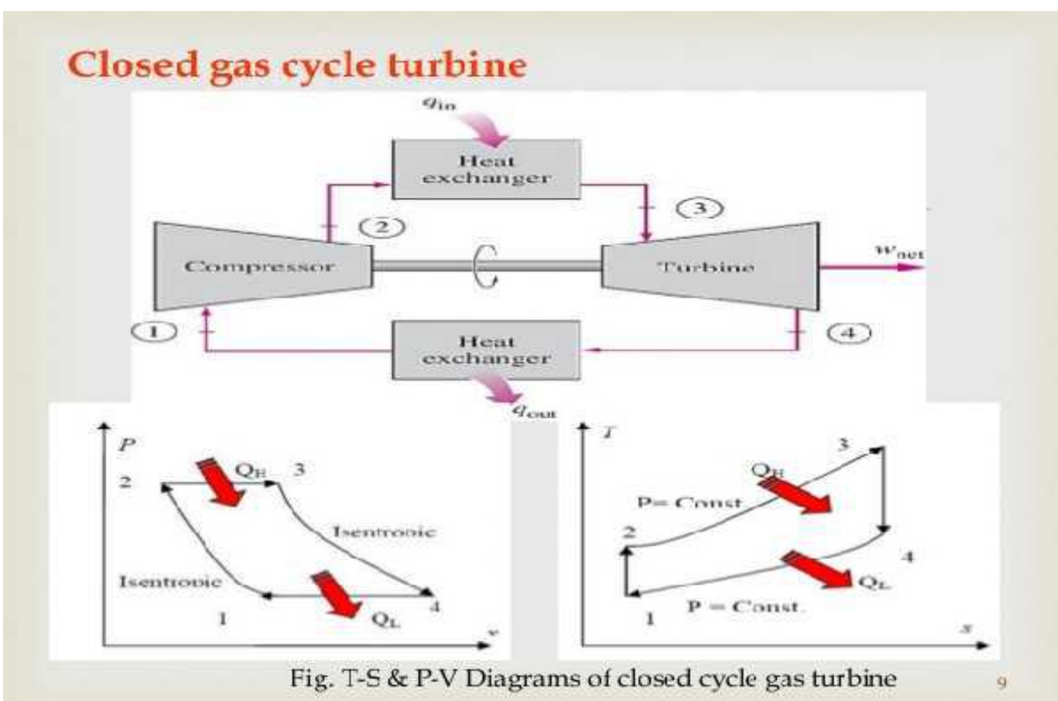
		increases to 00 C as shown in figure by process a-b.in this stage solid phase exists. **ii) Solid+ Liquid phase-** The point b is called is saturation point when heat is further added this heat cannot increase the temperature but ice is converted into water that means phase transformation takes place, thus in-between region b-c, solid and liquid phase exists. **iii) Liquid phase**- From point c-further heat is added up to 1000 C, in this region no phase change takes place, there is only liquid phase present. **iv) Liquid+ Vapour phase**- Point d is saturation point; further addition of heat will not increase the temperature but liquid phase change into vapors phase. In this region only liquid and vapour is present. **v) Vapour phase**- Point e is called as saturation point, further adding heat increase the temperature of steam which is called as superheating and in this region only vapour is present.  Fig. Formation of steam	02 02
	(e)	**Enlist factors affecting volumetric efficiency of reciprocating aircompressor.**	**04**
	ANS:	**Answer: Factors affecting volumetric efficiency of reciprocating air compressor** *(any four):* 1) Clearance Volume 2) leakages at valves 3) Speed of compressor 4) Piston ring leakages 5) Temperature inside the cylinder 6) Expansion of fresh air by contact with hot wall.	**04**
	(f)	**State the advantages of closed gas turbine plant over open type gas turbine plant.**	**04**
	ANS:	Answer: **Advantages of closed gas turbine plant over open type gas turbine plant**. *(Any four)* 1. Any type of working fluid with better thermodynamic properties can be used. 2. Working fluid circulated continuously. 3. Mass of installation per KW is more.	

		4. Any type of fuel is used. 5. It avoids erosion of turbine blade due to contaminated gases. 6. The exhaust gas from the turbine is passed into cooling chamber.	04
03		**Attempt any FOUR of the following**	16
	a)	State the classification of air compressor.	04
			04
	b)	Explain Brayton cycle with P-V & T-S diagram.	04
			02
		The Brayton cycle is a theoretical cycle for simple gas turbine. This cycle consists of two isentropic and two constant pressure processes. Above Fig. Shows the Brayton cycle on p-v and T-s coordinates. The cycle is similar to the Diesel cycle in compression and heat addition. The isentropic expansion of the Diesel cycle is further extended followed by constant pressure heat rejection. The thermal efficiency is given by,	02

		$$\eta_{th} = \frac{\text{Heat added - Heat rejected}}{\text{Heat added}}$$ $$\eta_{th} = \frac{mC_p(T_3 - T_2) - mC_p(T_4 - T_1)}{mC_p(T_3 - T_2)} = 1 - \frac{T_4 - T_1}{T_3 - T_2}$$	
	c)	Explain with neat sketch 'Thermal Power Plant'.	04
		Answer: **Thermal Power Plant :**	02



		In above figure shows major components of thermal power plant which are namely as i) Boiler, ii) Steam turbine, iii) Electric generator, iv) Condenser, v) Combustion chamber, vi) Feed pump etc; Generally for run such type of power plant we can use fuel in form of solid (i.e. coal), liquid (oil) (or) gaseous for the production of steam. Here steam is generated using storage energy in fuel. Initially fuel is supplied into combustion chamber for combustion process. After combustion this heat is given to boiler. Due to this heat water is converted into steam. Now this steam is used to run steam turbine. This steam turbine is directly connected to electrical generator which is used to produce electrical energy. Now the steam coming out of turbine is allowed to pass through condenser in which it is condensed with the help of cooling water. Here condensate is again pumped to boiler for the formation of steam. This type of plant works on closed cycle. Fluid is used again and again for the purpose of power generation. In India Coal is used for run thermal power plant. Oil is used in U.S.A. and gas is used in Canada. Choice of fuel based on availability and economy of country.	02
	d)	Define ultimate analysis & proximate analysis of coal; explain how sampling of coal is done in boiler in boiler trial.	**04**
		Ultimate Analysis: Ultimate analysis is complete breakdown of coal into chemicalconstituents. This analysis is important for large scale trials. It serves the basis forcalculation of the amount of air required for complete combustion of 1kg of fuel. Itgives percentage content on mass basis of carbon, hydrogen, oxygen, Sulphur andash. We are able to calculate the Calorific value of coal. In ultimate analysis a complete breakdown of coal into its chemicalconstituents 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 forcomplete combustion of 1 Kg. of coal.This analysis gives percentage of carbon, hydrogen, oxygen, sulphurand ash on mass basis their sum is taken as equal to 100%. In this analysis moisture is consider as	02

		separate item.This analysis is also used to determine calorific value of the coal. **Proximate Analysis:** Proximate analysis is complete breakdown of coal into physicalconstituents without knowledge of analytical chemistry. This analysis made bymeans of a chemical balance &temperature control Furnace. The component in theanalysis is fixed carbon volatile matter, moisture& ash. This is used to calculate theheating value of coal. In this analysis separation of coal into its physical components. Thisanalysis made by means of chemical balance and temperature controlledfurnace.In this analysis sample is heated into furnace. The components inanalysis are fixed, carbon, volatile matter, moisture and ash.These components are expressed in percentage on mass basis andtheir sum is taken as 100% sulphur is determined separately. This analysisalso used to determine heating value of the coal.	02
	e)	Explain with neat sketch closed cycle gas turbine	04
		 Fig. T-S & P-V Diagrams of closed cycle gas turbine In above figure shows a closed cycle gas turbine which consists of compressor, heating	02

		chamber gas turbine which drives the generator, compressor and a cooling chamber. In this turbine air is compressed isentropically and then passed into heating chamber. The compressed air is heated with the help of some external source and made to flow over turbine blades. The gas while flowing over the blades gets expand from the turbine gas is passed to cooling chamber where it is cooled at constant pressure with the help of circulating air is circulated through compressor.	02
	f)	A sample of coal has the following composition by mass carbon 75%, hydrogen 6%,oxygen 8%, nitrogen 2.5%, sulphur 1.5%, & ash7%.calculate its higher and lower calorific values per kg of coal.	**04**
		Soln : Given **Composition of coal on mass basis.** Carbon (C) = 75% = 0.75 Hydrogen (H2) = 6% =0.06 Oxygen (O2) = 8% = 0.08 Nitrogen (N) = 2.5 % = 0.025 Sulphur(s)=1.5%=0.015 Ash = 7% = 0.07 We know Dulong's formula. **1)** H.C.V. of Coal = 33800 C+144000 (H2 - O2/8) +9270 S KJ/Kg. = 33800 x 0.75 + 144000 (0.06 – 0.085/8) + 9270 x 0.015 = 25350 + 7200 + 139.05 H.C.V. = 32689.05 KJ/Kg. **2)** L.C.V. of Coal = H.C.V. – 9 H2 x 2466 KJ/Kg. = 32689.05 – 9 x (0.06) x 2466 = 32689.05 – 1331.64 L.C.V. = 31357.41 KJ/Kg.	**02** **02**

4		**Attempt any TWO of the following:**	**16**
	a)	Derive relation between P,V,& T during adiabatic process.	08

Pressure (P) , Volume (V) & Temperature (T) relation for adiabatic process:

For adiabatic Process,

$PV^{\gamma} = C$

$P_1 v_1^{\gamma} = P_2 v_2^{\gamma}$

$\frac{P_2}{P_1} = (\frac{V_1}{V_2})^{\gamma}$ .... (1) — 02

From general gas equation

$\frac{PV}{T} = C$

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\frac{T_2}{T_1} = \frac{P_2 V_2}{P_1 V_1}$ ....(2)

From (1)

$\frac{V_2}{V_1} = (\frac{P_1}{P_2})^{1/\gamma}$ .... (3) — 02

Put equation (3) into equation (2)

$\frac{T_2}{T_1} = \frac{P_2}{P_1} (\frac{P_1}{P_2})^{1/\gamma}$

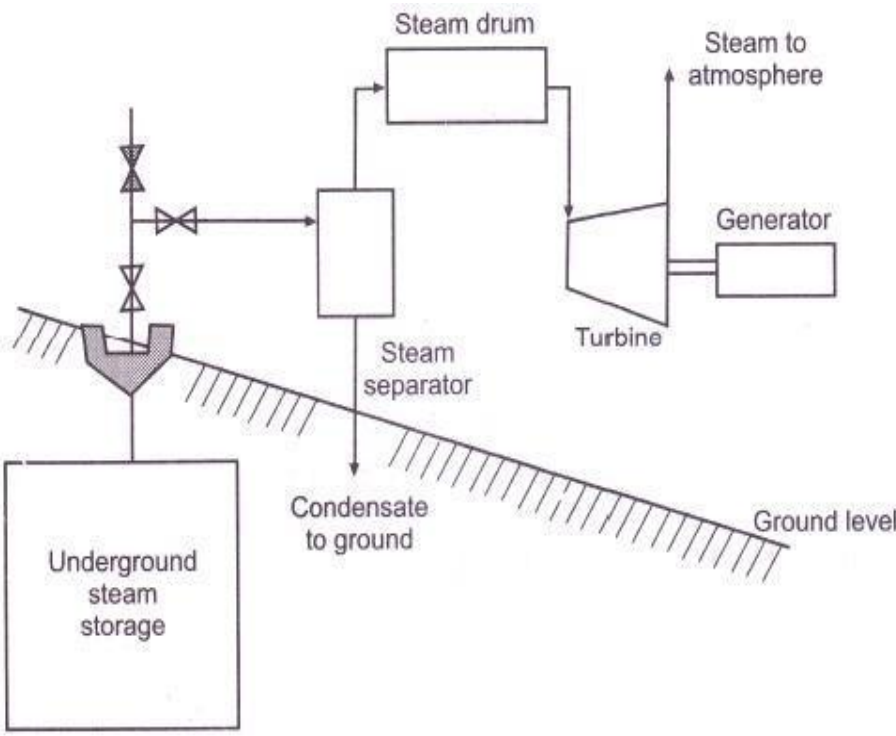
$\frac{T_2}{T_1} = (\frac{P_2}{P_1})^{\frac{\gamma-1}{\gamma}}$

$\frac{P_2}{P_1} = (\frac{T_2}{T_1})^{\frac{\gamma}{\gamma-1}}$ ....(4) — 02

From equation (1) & (4)

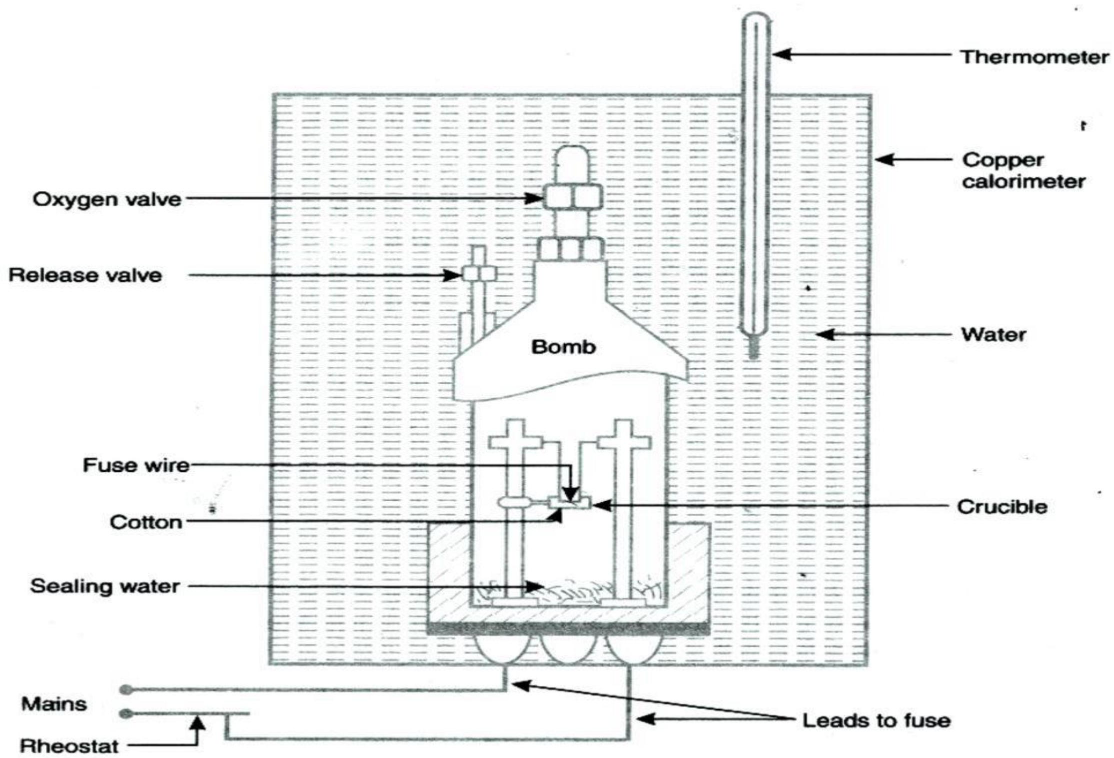
$\frac{P_2}{P_1} = (\frac{V_1}{V_2})^{\gamma} = (\frac{T_2}{T_1})^{\frac{\gamma}{\gamma-1}}$

$$\boxed{\frac{P_2}{P_1} = (\frac{V_1}{V_2})^{\gamma} = (\frac{T_2}{T_1})^{\frac{\gamma}{\gamma-1}}}$$ — 02

	b)	Attempt the following :	08
	i)	Explain the working of geothermal power plant with a neat sketch.	04
		 **Fig:-Geothermal power plant**	02
		Figure shows geothermal power plant which consists of the following main components: Underground steam storage, steam separator, steam separator, turbine and Generator. Steam is present in the earth crust at 10 km depth is about 2000 C. It is stored in the underground steam storage tank. This steam is taken out through pipe and valve and passed through steam separator. In steam separator moisture content in the steam is taken out and dry steam is allowed to pass in steam drum where steam is stored. The moisture content in steam is then injected into the ground. As per requirement steam is passed over the turbine and kinetic energy of steam is converted into mechanical work. Turbine is connected to the generator by shaft which generates power. Mechanical energy of shaft is converted in to electrical energy by generator.	02

	ii)	Compare solid fuel & gaseous fuel (any four points)	04
	ANS:	(table below)	04
	c)	Describe with neat sketch construction and working of Bomb calorimeter. Write Dulong's formula & state its use.	08
		(sketch below)	03

Sr.No.	Solid Fuels	Gaseous Fuel
01	Required Large space	Required Large space
02	Low calorific value	Low calorific value
03	For combustion more air is required	For combustion less air is required
04	Produce ash & smoke after combustion	Do not Produce ash & smoke after combustion
05	Low cost	High cost
06	Impure form	Pure form



The calorific valve of solid and liquid fuels is determined in the laboratory by „Bomb calorimeter" It is so named shape resembles that of bomb .Fig shows the schematic sketch of bomb calorimeter.

Construction: 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 temperature up to accuracy of0.0010 C is fitted through the lid of the calorimeter. The heat released by the fuel oncombustion is absorbed by the surrounding water and the calorimeter. From the abovedata the calorific value of the fuel can be found. 03

Dulong's formula used to calculate the theoretical calorific value of fuel if ultimate analysis available and the calorific value of elementary combustibles are known.

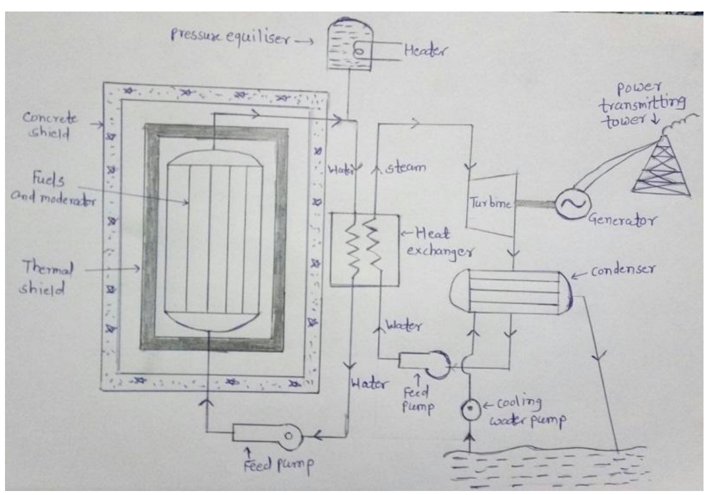
Theoretical calorific Value of fuel =33800 C + 144500 ($H_2 - \frac{O_2}{8}$) + 9300 S kJ/kg 02

Where C, H_2 O_2 & S repents the mass of carbon, hydrogen, oxygen and sulfur in kJ/Kg

Q.5 **Attempt any <u>TWO</u> of the following.** **16**

(a) Explain with neat sketch construction and working of pressurized water reactor. List any four parameters for site selection of nuclear power plant. **08**

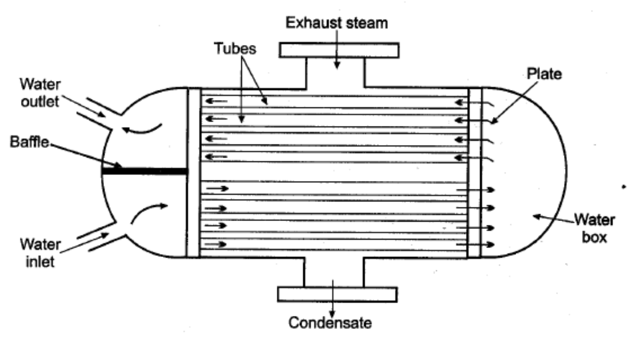
Answer: Figure- 04 marks, Construction and working- 02 marks, Parameters- 02 marks

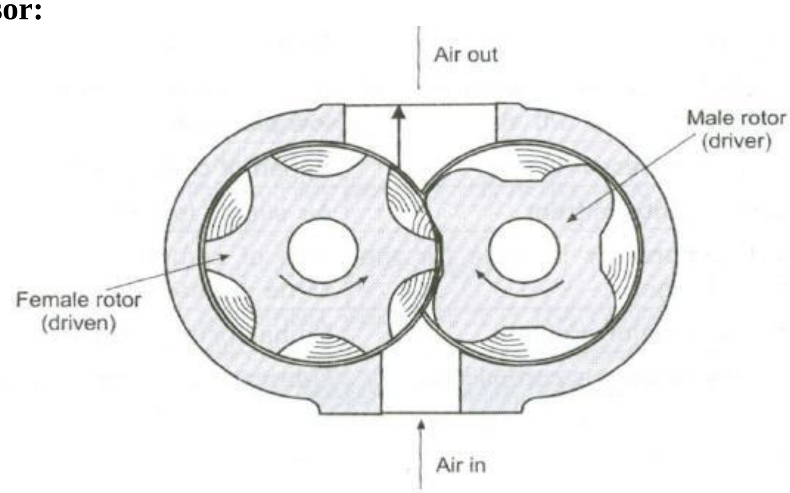


04

Fig. Nuclear power plant (Pressurized water reactor) Credit should be given to equivalent figure

Construction and working: A pressurized water nuclear plant is shown in fig. It uses enriched uranium as fuel. The heat liberated by nuclear fission of uranium is absorbed by **02**

		water coming from heat exchanger through circulating pump. This heat is given to water coming from condenser through feed pump in heat exchanger and this water get converted into steam . This steam is expanded in turbine and mechanical energy is produced. Generator coupled converts mechanical energy into electrical energy. The low pressure steam get converted into water in condenser. The electricity generated is distributed through power transmitting tower. ***(Note: credit should be given to only list of any four factors also.)*** **Factors to be considered while selecting the site for nuclear power plant:*(any four)*** 1. **Availability of fuel:** Fuel source should be available on mass scale and near to the power plant. 2. **Availability of water:** Water source should be available on mass scale and near to the power plant. 3. **Transportation facilities:** Power plant should have transportation facilities like road or rail nearby. 4. **Land:** The Conventional power station should be located at a place where land is cheap and further extension, if necessary, is possible. Moreover, the bearing capacity of the ground should be adequate so that heavy equipment could be installed. 5. **Nearness to load centers:** In order to reduce the transmission cost, the plant should be located near the centre of the load. 6. **Location:** Power plant should be located away from populated area. 7. **Cost**- Cost should be low. 8. **Availability of labor** 9.There must be sufficient space near the plant site for the storage of radio-active waste for short time during the working of plant.	**02**
	(b)	Explain with neat sketch two pass down flow surface condenser. State functions of condenser in thermal power plant.	**08**
		Answer: Figure-03 marks, Working- 03 marks, Functions- 02 marks.  **Figure. Two pass down flow surface condenser** **Working-** 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 center condensing space is prevented. 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.	**03**

		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. **Function: 1.** The primary function of steam condenser is to maintain a low back pressure on the exhaust side of steam turbine. **2.** The secondary function of steam condenser is to supply pure feed water tothe boiler.	**03** **02**
	(c) (i)	Explain construction and working of screw compressor.	**04**
		Answer: Figure-02 marks, Construction-01 marks, Working- 01 marks, **Note- credit should be given to equivalent figure.** **Screw compressor:**  Fig. Screw Compressor **Construction:** It consists of two mutually engaged helical grooved rotors which are suitably housed in a casing. Out of two rotors male rotor is driver and female rotor is a driven. Male rotor has four lobes and female rotor as six flutes. **Working:** During rotation of rotor, air enters and takes space between male and female rotor. This air traps and moves axially and radically with rotation of rotors and gets compressed due to volume reduction. Then this air discharged from upward direction. Speed of rotors is different due to different number of lobes and flutes. It handles 3.5 to 300 m3/min and maximum pressure ratio of 20. This system requires lubrication. This compressor is noisy In operation. Used in refrigeration industry.	**02** **01** **01**
	(ii)	Differentiate between centrifugal and axial flow compressor.	**04**

Answer: Difference between centrifugal and axial flow compressor (any four pints) — 04

Sr. No.	Centrifugal compressor	Axial flow compressor
1	Flow is radial	Flow of air axial
2	Multistaging is difficult	Multistaging is simple
3	Requires low starting torque	Requires high starting torque
4	It is having larger frontal area	It is having less frontal area
5	Isentropic efficiency is 70%	Isentropic efficiency is 80%
6	Low manufacturing and running cost	High manufacturing and running cost
7	This is more compact	This is less compact
8	Pressure ratio per stage is 4:1	Pressure ratio is 1.1 to 1.2
9	It is used in turbojet engine, refrigeration cycle .	It is used in gas turbine power plants.
10	Construction is simple	Construction is complicated

6. **Attempt any FOUR of the following.** — 16

(a) State the air standard efficiency of Otto & Diesel cycle. — 04

Answer:-

Otto cycle- Air standard efficiency

$$\eta = 1 - \frac{1}{r^{\gamma-1}}$$

Where, r = compression ratio

γ = specific heat ratio

02

Diesel cycle- Air standard efficiency

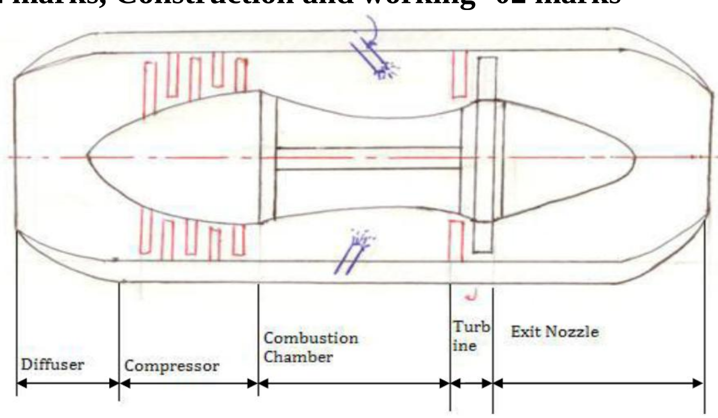
$$\eta = 1 - \frac{1}{(r)^{\gamma-1}}\left[\frac{\rho^{\gamma}-1}{\gamma(\rho-1)}\right]$$

ρ = Cut –Off ratio

r = compression ratio

γ = specific heat ratio

02

	(b)	Explain sources of air leakage in condenser.	**04**
		Answer:- Sources of air leakage in condenser : 1. Leakage from atmosphere at various joints of parts because inside pressure is less than outside atmospheric pressure. 2. The dissolved air in the feed water enters into the boiler from where it passes to the condenser with exhaust steam. 3. In jet condensers dissolved air with injection water enters into the condenser. 4.Air leaks if any bypass seal is broken.	**01 Mark each**
	(c)	Define following terms related to compressor. i) I.P. ii) B.P. iii) Volumetric efficiency iv) Compressor efficiency	**04**
		Answer: **i) I.P.** –The power available for compression in polytropic compression is known as indicated power. Or It is the ratio of polytrophic work into speed of compressor in revolution per second. **ii) B.P.**-The power supplied by electric motor at the crankshaft or power required to drive the compressor is known as brake power. **iii) Volumetric efficiency -** It is defined as the ratio of actual volume (F.A.D.) to theoretical (swept or stroke or displacement) volume. **iv) Compressor efficiency** - For the same pressure ratio, It is the ratio of theoretical isothermal work to the actual work required to drive the compressor. Or It is the ratio of isothermal power to shaft or brake power.	**01 Mark each**
	(d)	Explain construction and working of turbojet engine with neat sketch.	**04**
		Answer: Figure-02 marks, Construction and working- 02 marks  **OR**	**02**

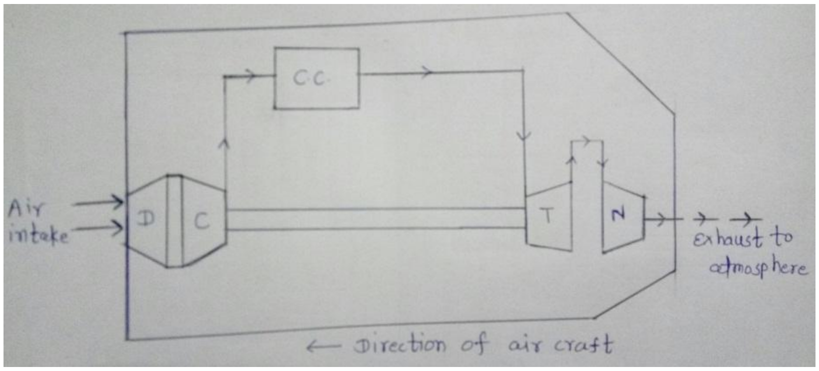


Figure: Turbojet Engine

D = Diffuser
C = Compressor
C.C. = Combustion Chamber
T = Turbine
N = Nozzle

Construction and working:

Turbo-jet engine consists of diffuser, compressor, combustion chamber, turbine and nozzle.

As engine starts air enters in the diffuser where it slows down and part of kinetic energy is converted into pressure energy. The air enters into the compressor and get compressed. This compressed air enters into the combustion chamber where it is mixed with the fuel. The combustion takes place at constant pressure. The hot gases enters gas turbine where partial expansion takes place. The power produced is just sufficient to drive the compressor. The hot gases are then expanded in nozzle and very high velocity jet is produced which gives forward motion to the air craft. **02**

(e) Compare reciprocating and rotary air compressor on the basis of **04**

i)Maximum delivery pressure ii)Speed
iii)Air supply iv)Size

Answer: Each aspect 01 mark.

01 Mark each

Sr. No.		Reciprocating air compressor	Rotary air compressor	
1	Maximum Delivery pressure	It is up to 1000 bar.	It is up to 10 bar.	
2	Speed	Speed is low.	Speed is high.	
3	Air supply	Air supply is intermittent.	Air supply is continuous.	
4	Size	Size of compressor is large for the given discharge.	Size of compressor is small for the same discharge.	

	(f)	Give classification of gas turbines.	**04**
		Answer: Classification of gas turbine: (Any four) 1. According to the path of the working substance or cycle of operation: i) Open cycle gas turbine ii) Close cycle gas turbine 2. According to process of combustion or heat absorption: i) Constant pressure gas turbine ii) Constant volume gas turbine 3. According to direction of flow: i) Radial flow ii) Axial flow iii) Tangential flow 4. According to principle of action of expanding gases: i) Impulse turbine ii) Reaction turbine 5. According to their usage: i) Constant speed ii) Variable speed 6. According to fuel used: i) Solid fuel gas turbine ii) Liquid fuel gas turbine iii) Gaseous fuel gas turbine 7. According to position of shaft: i) Horizontal shaft gas turbine ii) Vertical axis gas turbine	**04**

		8. According to working cycle: i) Brayton cycle gas turbine ii) Atkinson cycle gas turbine iii) Ericsson cycle gas turbine 9. According to application: i) Stationary gas turbine ii) Mobile gas turbine	