MODEL ANSWER

Summer – 17 EXAMINATION

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 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 judgment 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 Que.	Answer	Marking Scheme
1	A	Attempt any six of the following	**12**
1A	**a**	Define entropy and enthalpy.	**2**
	Ans.	**Entropy** : Entropy is defined as a thermodynamic property of a working substance which increase with addition of heat and decreases with removal of heat. Entropy is represented by symbol "S". Change in entropy can be expresses as $\Delta S=\frac{dQ}{T}$ Where T= absolute temperature dQ= change in heat ΔS= change in entropy. **Enthalpy:** Enthalpy is defined as the total heat content or total useful energy of a substance. The symbol for enthalpy is "**h**." Enthalpy is also considered to be the sum of internal energy "**u**" and flow energy (or flow work) **p.V**. This definition of enthalpy can be expressed, mathematically, as follows: **h = u + p.V** Where, **h =** Specific enthalpy, measured in **kJ/kg (**SI Units) **u =** Specific internal energy, measured in **kJ/kg** (SI Units) **p.V =** Flow Energy, Flow Work or p-V work, quantified in **kJ/kg** (SI Units)	**1** **1**

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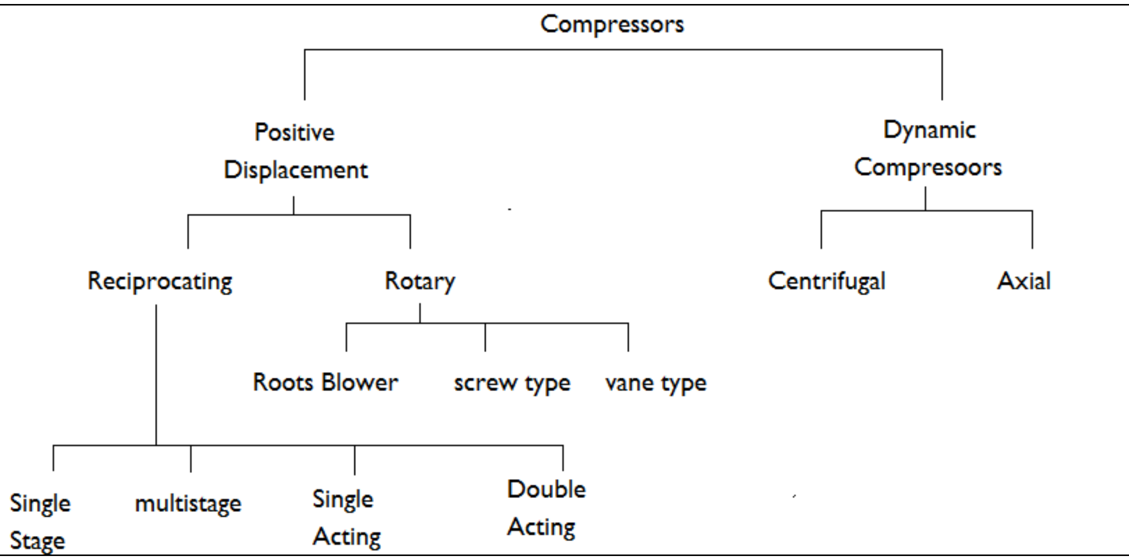
1A	**b**	Define Dryness fraction and degree of superheat.	**2**
	Ans.	**Dryness fraction:** Dryness fraction is defined ratio of the mass of the dry steam present in the total mass of steam. Or *Dryness fraction is ratio of the mass of actual dry steam to the mass of wet steam.* Therefore, x = $\frac{m_s}{m_s+m_w}$ 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.	**1** **1**
1.A	**c**	Give classification of compressors.	**2**
	Ans.		**2**
1.A	**d**	Enlist any four applications of compressed air.	**2**
	Ans.	**Application of compressed air:** *(Any four)* 1. Operating tools in factories 2. Operating drills and hammers in road building 3. Starting diesel engines 4. Operating brakes on buses, trucks and trains 5. Spray painting 6. Excavating **7.** To clean the large workshops **Etc.**	

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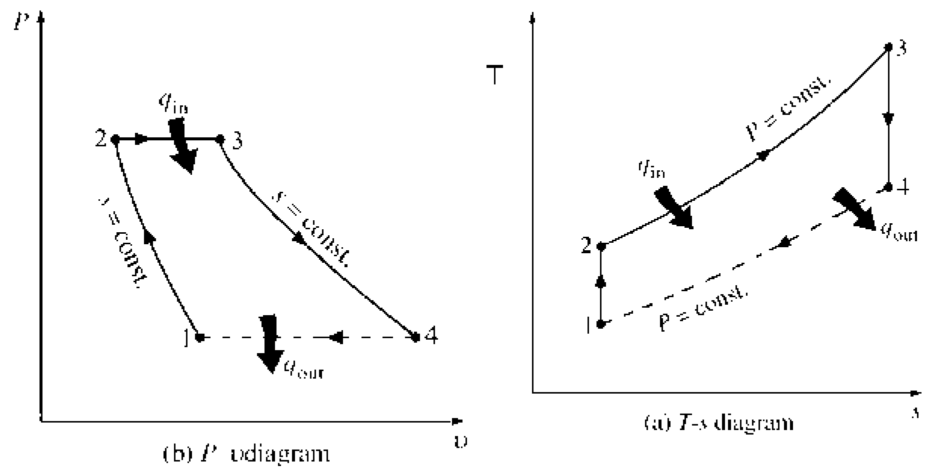
1.A	e	Plot P-V and T-S diagram for open cycle gas turbine.	**02**
		(b) P υdiagram (a) T-s diagram Open cycle gas turbine	**02**
1.A	f	Give classification of renewable Energy sources.	**02**
		Renewable energy sources are classifies as: **(any four, 02 marks)** 1. Wind power 2. Biomass 3. Solar applications of energy 4. Hydraulic power 5. Fuel cells 6. Bio fuels	**02**
1A	g	List any four merits of liquid fuels over gaseous fuels.	
	Ans.	**Merits of liquid fuels over gaseous fuels: (*For Any four points 02 marks)*** **i)** Comparatively Less space required to storage. ii) Comparatively Less chance of explosion. iii) There is no loss of heat during storage. iv) Comparatively less inflammable. v) Comparatively easy to handle. vi) Comparatively low cost.	**02**
1A	h	Enlist any four types of gaseous fuels.	**02**
	Ans.	**Types of gaseous fuels:** *(Any four)* 1) Natural fuel 2) CNG 3) LPG 4) Water gas 5) Producer gas 6) Coal gas 7) Blast Furnace gas 8) Coke oven gas 9) Oil gas	**02**

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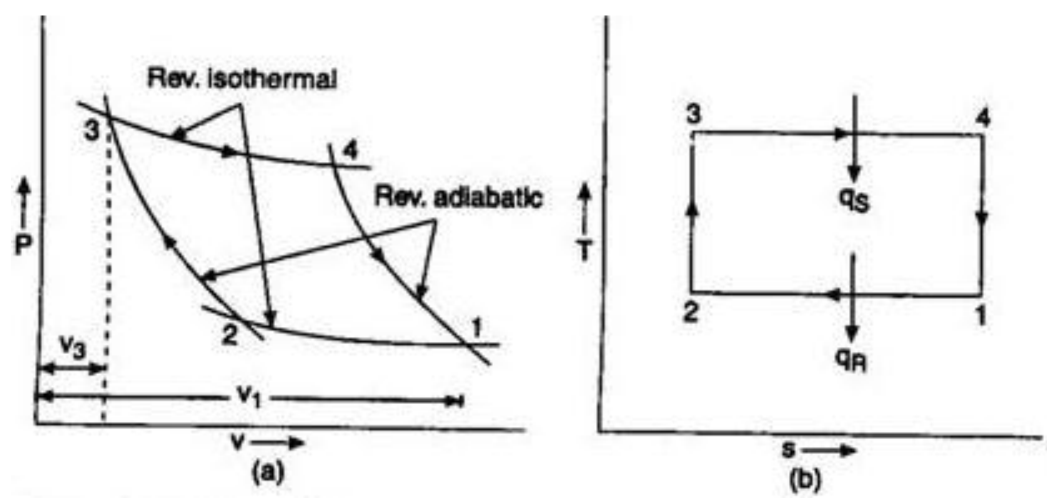
1	**B**	**Attempt any two of the followings.**	**08**
1B	**a**	**Represent Carnot cycle on P-V and T-S diagram and write equation for air standard efficiency.**	**04**
	Ans.	 **Carnot cycle on P-V and T-S diagram**	**02**
		Air standard efficiency of Carnot Cycle:- $\eta = (T1-T2) / T1$ Where, T1= temperature of source T2= temperature of sink	**02**
1B	**b**	**Explain Latent heat and Sensible heat.**	**04**
	Ans.	**Latent heat**: It is defined as the quantity of heat required for phase change of working substance at saturation temperature. OR The amount of heat added at saturation temperature is called latent heat. Latent heat is usually expressed in kJ/kg. Depending upon the change in state which a substance undergoes, different names have been given to this latent heat. They are as given in Table.	**02**

Sr. No.	Change of state	Hat added/removed	Type of latent heat
1	Solid to liquid	Added	Latent Heat of fusion
2	Liquid to solid	Removed	Latent heat of solidification
3	Liquid to vapour	Added	Latent heat of evaporation / vaporization
4	Vapour to liquid	Removed	Latent heat of condensation

Sensible heat: It is defined as the quantity of heat which can be sensed by the thermometer. OR The amount of heat added up to saturation temperature is called sensible heat. The word 'sensible' itself suggest that, it is the heat which can be sensed. As opposed to latent heat, it is the heat responsible for changing the temperature of a substance. Change in temperature can be sensed/perceived and hence it got the name as sensible heat. **02**

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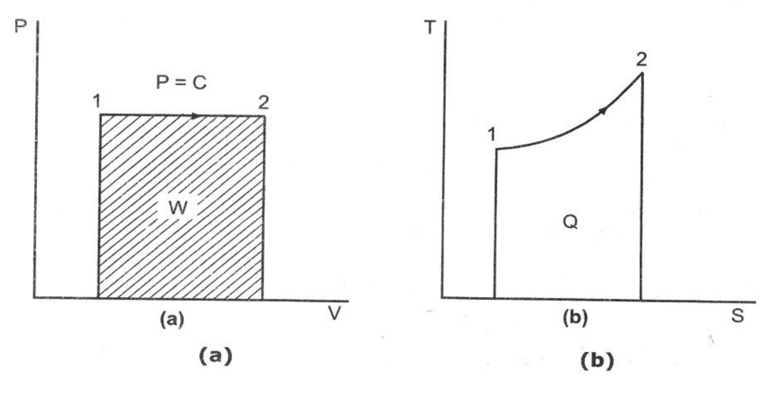
1B	**c**	**Give classification of gas turbine.**	**04**
	Ans.	**Classification of gas turbine: (*Note: Any four points.)*** **1. According to the path of the working substance:** i) Open cycle gas turbine ii) Close cycle gas turbine iii) Semi-closed cycle gas turbine **2. According to process of combustion:** 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	
2		**Attempt any four of the following:**	**16**
2	**a**	**Plot isobaric process with help of P-V and T-S diagram. Write formula for workdone and Internal Energy.**	**04**
		Isobaric Process  P-V diagram T-S diagram	**02**

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		Formula for Workdone: $W=P(V_2-V_1)=mR(T2-T_1)$	**01**
		Formula for Internal Energy: Change in intermnal energy during isobaric process is given as $dU= m C_v \ (T2-T_1)$	**01**
2	**b**	**Differentiate between conduction and convection.**	**04**
	Ans.	**Difference between conduction and convection (for any four point, 4marks)**	**04**

Sr. No.	**Conduction**	**Convection**
1	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.	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.
2	It is the mode of heat transfer in which fluid particles do not mix with each other.	It is the mode of heat transfer in which fluid particles mix with each other.
3	It occurs in solid.	It occurs in liquid and gases.
4	It governs by Fourier's law of heat conduction.	It governs by Newton's law of convection heat transfer.
5	Example: Heat flow from one end to other end of metal rod.	Example: Heat flow from boiler shell to water.

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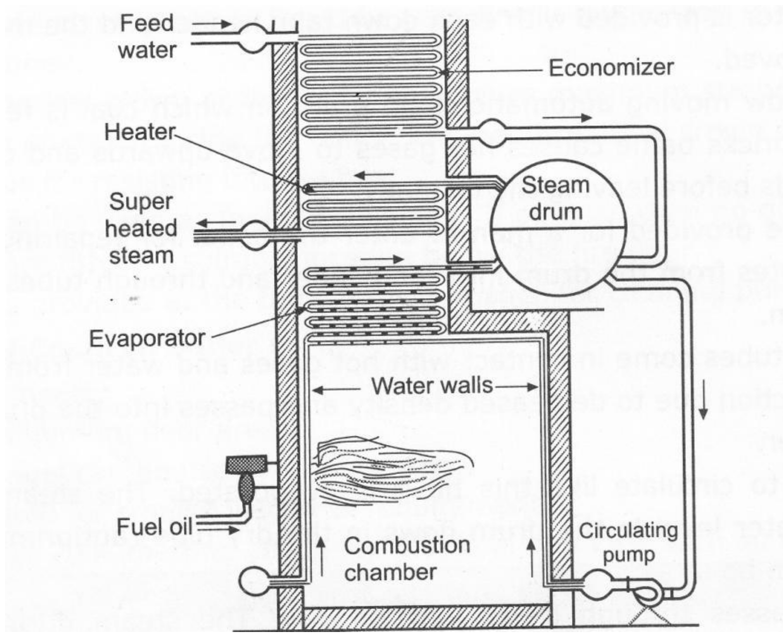
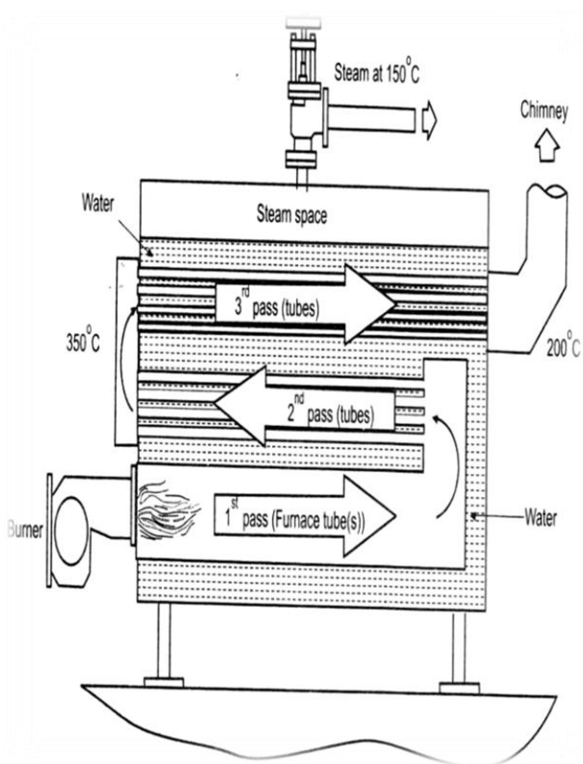
2	c	**Draw neat labeled sketch of La-Mont Boiler.**	04
	Ans.	 **La-Mont Boiler**	04
2	d	**Draw neat labeled sketch of three pass packaged type boiler.**	04
		 **Three pass packaged type boiler**	04

Q.	Sub	Answer	Marks
2	e	**Define the following:** **(i)Capacity of compressor (ii)Volumetric efficiency** **(iii) Piston Displacement (iv) Compressor Efficiency**	04

(i) **Capacity of compressor:** It is the quantity of free air actually delivered by the compressor and expressed in m^3/min or m^3/s. **1**

(ii) **Volumetric efficiency:** It is the ratio of free air delivered per stroke to the swept volume of the piston. **1**

Volumetric efficiency is given as

$$\eta_v = \frac{\text{Volume of free air delevered per stroke}}{\text{swept volume of the piston}}$$

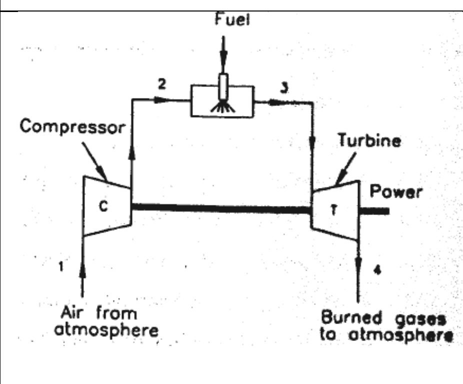
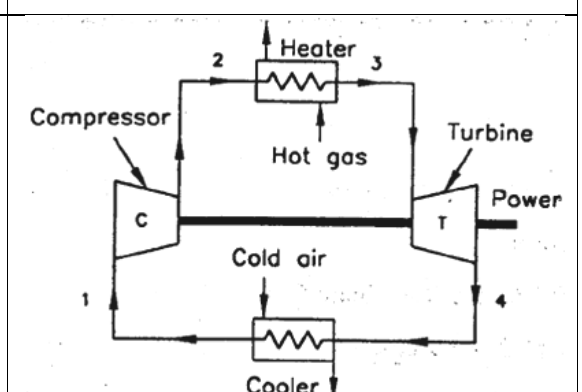
(iii) **Piston Displacement:** This is the volume swept by the piston in moving from T.D.C. to B.D.C. this is also called swept volume If "d" is the cylinder bore and "L" the stroke, the piston displacement V_s is given by **1**

$$V_s = \frac{\pi}{4} d^2 L$$

(iv) **Compressor Efficiency:** It is the ratio of isothermal work (or power) required to drive compress to the actual work required to drive compressor for the same pressure ration. Mathematically compressor efficiency is given as **1**

$$\eta_c = \frac{\text{Isothermal Power}}{\text{Indicated power}}$$

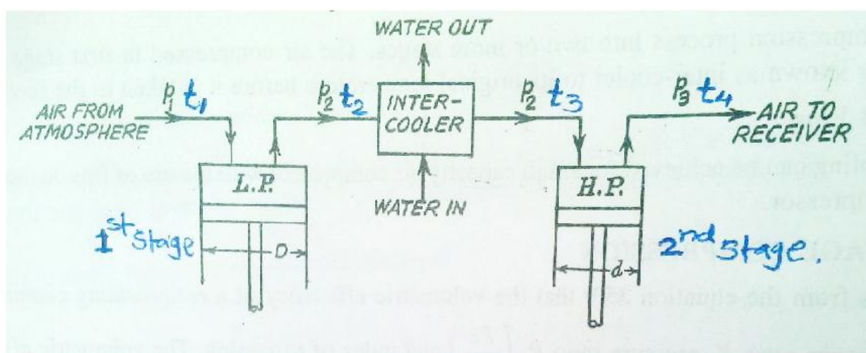
Q.	Sub	Question
2	f	**Give comparison of open cycle and closed cycle gas turbine.**

Sr. No.	**Open cycle gas turbine**	**Closed cycle gas turbine**
		
2	Only air can be used as a working fluid.	Any type of working fluid with better thermodynamic properties can be used.
3	Maintenance cost is low.	Maintenance cost is high.
4	Working fluid replaced continuously	Working fluid circulated continuously
5	Mass of installation per KW is less	Mass of installation per KW is more.

6	Pure form of fuel should be used	Any type of fuel is used.
7	Heat exchanger is not used	Heat exchanger is used.
8	The turbine blades wear away earlier as it gets contaminated with air	It avoids erosion of turbine blade due to contaminated gases
9	The exhaust gas from the turbine is exhausted to the atmosphere	The exhaust gas from the turbine is passed into cooling chamber.
10	This system required less space	This system required more space.
11	Since turbine exhaust is discharged into atmosphere, it is best suited for moving vehicle.	Since exhaust is cooled by circulated water, it is best suited for stationary installation, marine use

03		**Attempt any FOUR of the following:**	**16**
3	**a**	**Describe working of two stage reciprocating air compressor.**	**04**

Answer:

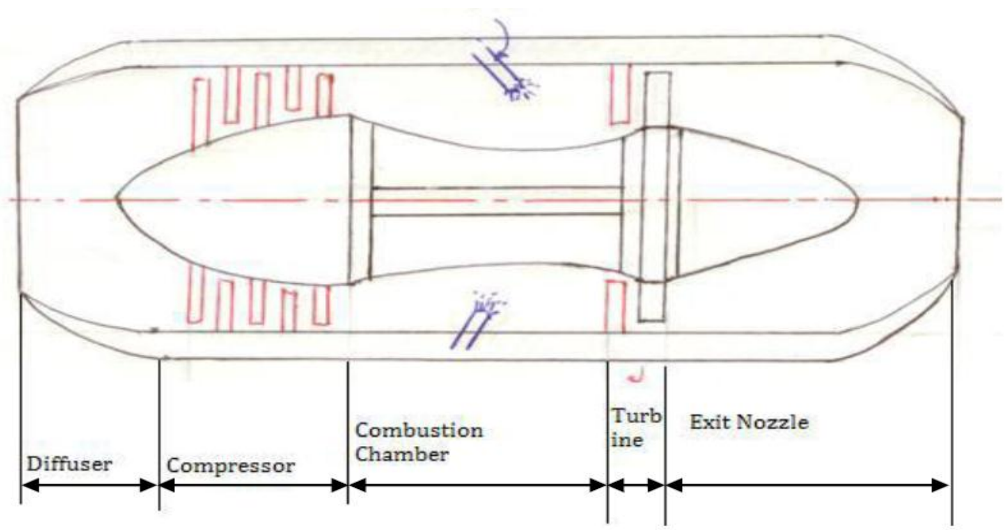


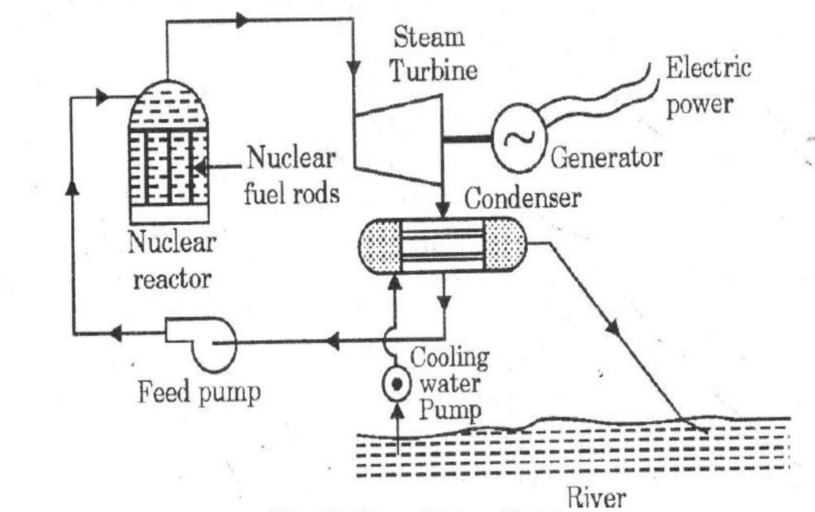
02

In above fig. shows two stage reciprocating air compressor with water cooled intercooler.

First of all fresh air is sucked from atmosphere in low pressure (L.P.) cylinder during its suction stroke at inlet pressure p_1 and Temperature t1.
The air after compression in L.P. cylinder (1st stage) from 1 to 2 is delivered to intercooler at pressure p_2 and Temperature t_2.
Now air is cooled in intercooler from 2 to 3 at constant pressure p_2 and from Temperature t_2 to t_3.
After that air is sucked in high pressure (H.P.) cylinder during its suction stroke.
Finally air after further compression in H.P. cylinder (i.e. second stage) from 3 to 4 is delivered by the compressor at pressure p_3 & Temperature t_4.

02

3	**b**	**Explain with neat sketch turbojet engine.**	**04**
	Ans.	Answer: Turbo-jet Engine: Turbo-jet engine consists of diffuser, compressor, combustion chamber turbine and nozzle. At entrance air diffuser causes rise in pressure in entering air by slowing it down. A rotary compressor, which raises the pressure of air further to required value and delivers to the combustion chamber. The compressor is axial or radial type driven by turbine. In the combustion chamber, fuel is sprayed, as result of this combustion takes place at constant pressure and the temperature of air is raised. Then this product of combustion passes into the gas turbine gets expanded and provides necessary power to drive the compressor. The discharge nozzle in which expansion of gases is completed and thrust of propulsion is produced. The velocity in the nozzle is grater then flight velocity.  **Fig. Turbo-jet Engine**	**02** **02**

3	**c**	Draw neat labeled sketch of nuclear power plant.	**04**
	Ans.	Answer: **Nuclear Power Plant:**  **Fig. Nuclear Power Plant**	**04**
3	**d**	Explain the importance of non-conventional power generation system in the present situation of power shortage throughout the world.	**04**
	Ans.	Answer Due to the problems associated with the use of fossil fuels, alternative sources of energy have become important and relevant in today's world. These sources, such as the sun and wind, can never be exhausted and are therefore called renewable. Also known as non-conventional sources of energy, they cause less emission and are available locally. Their use can significantly reduce chemical, radioactive, and thermal pollution. They are viable sources of clean and limitless energy. Most of the renewable sources of energy are fairly non-polluting and considered clean that is why every body is looking for an alternative energy source to improve economy, to meet energy demand, to mitigate pollution, etc., (Manwell et al, 2007). Thus Renewable energy sources have the twin advantages of free availability and non-polluting nature.	**04**

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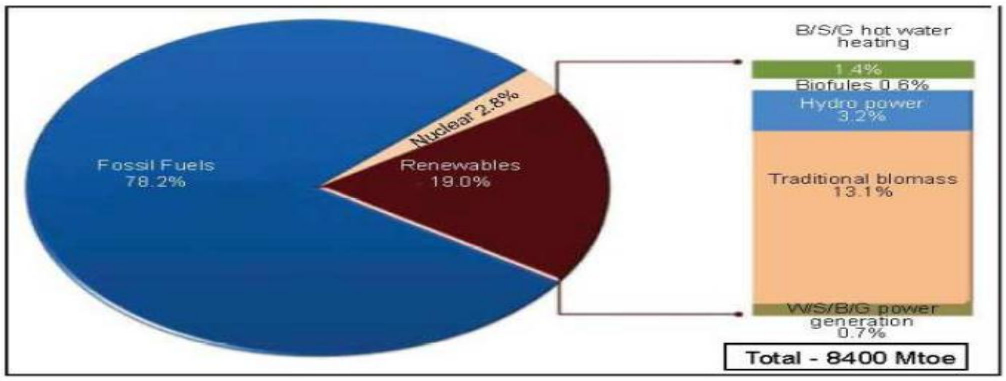


Renewable Energy Share in Global Energy Consumption

(Note: W-Wind; B-Biomass; S-Solar; G-Geothermal)

3 e Compare ultimate analysis and proximate analysis of solid fuels. — **04**

Ans. — **04**

Sr. No.	Ultimate analysis	Proximate analysis
01	Ultimate analysis is coal is complete breakdown of coal into chemical constituents	Proximate analysis is coal is complete breakdown of coal into physical constituents
02	This analysis gives percentage of carbon, hydrogen, oxygen, Sulpher and ash.	This analysis gives percentage of moisture, volatile matter, fixed carbon and ash.

3 f — **04**

During a boiler trial the coal analysis on mass basis was reported as :

$C = 62.4\%$, $H_2 = 4.2\%$, $O_2 = 4.5\%$, Moisture – 15% & ash – 13.9%.

Calculate minimum air required to burn 1 kg of coal. Also calculate higher and lower calorific value.

Soln : Given

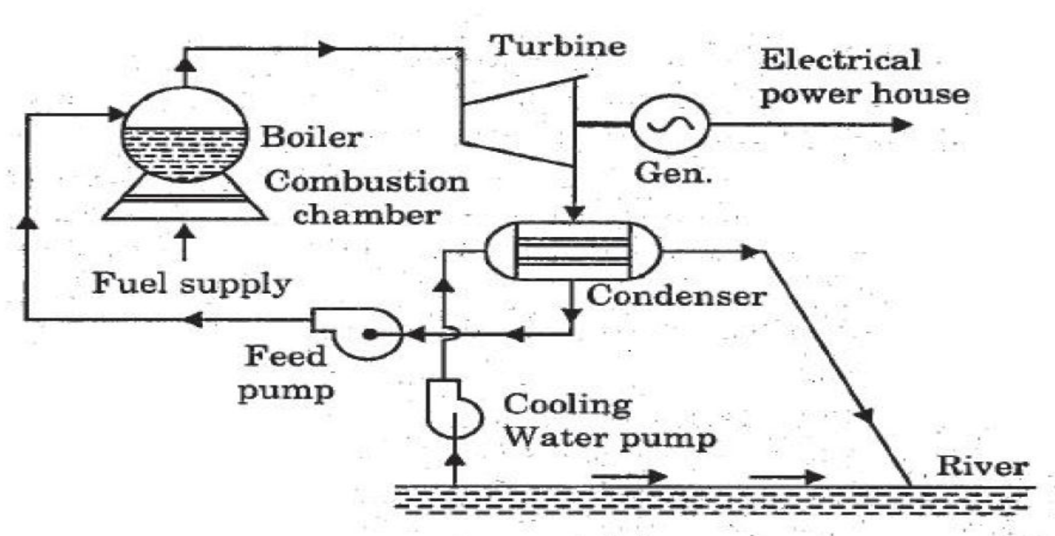
Composition of coal on mass basis.

Carbon (C) = 62.4 = 0.624

Hydrogen (H2) = 4.2% = 0.042

Oxygen (O2) = 4.2% = 0.045

Moisture = 15% = 0.15

		Ash = 13.9 = 0.139 Now, Minimum mass of air required for complete combustion of 1 Kg. of fuel. = 100/23 (2.67 C + 8 H2 + S – O2) Kg. = 100/23 (2.67 x 0.624 + 8 x 0.042 + 0 – 0.044) = 100/23 (2.136 + 0.264 + 0.009 – 0.004) = 100/23 (1.666 + 0.336 – 0.045) = 8.613 Kg. per Kg. of Coal burnt. We know Dulong's formula. H.C.V. of Coal = 33800 C +144000 (H2 - O2/8) + 9270 S KJ/Kg. = (33800 x 0.624) + [144000 (0.042 – 0.045/8)] + (9270 X 0) H.C.V. = 26329.2 KJ/Kg. L.C.V. of Coal = H.C.V. – 9 H2 x 2466 KJ/Kg. = 263329.2 – (9 x 0.042 x 2466 = 26329.2 – 932.148 = 25397.052 KJ/Kg	01 01 01 01
4		Attempt any TWO of following.	16
4	a	Describe construction of a thermal power plant with neat sketch and explain its working. What are the parameters to be taken into account for site selection of thermal power plant ?	08
	Ans.	**Thermal Power Plant :**  **Figure :- thermal power plant.**	02

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		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.	03
		Site selection for thermal power plant: 1) Availability of land, workers is very important. 2) For transportation of fuel power plant should be near to road track (or) rail facility. 3) For cooling purpose large amount of water is needed near to power plant. 4) Generally in India for run thermal power plant coal is used so power plant should be near to coal mines. 5) Ash disposal facility should be available. 6) There should be scope for future development. 7) Site should be safe and away from urban area. 8) Cost of land, infrastructure etc. should be minimum.	03

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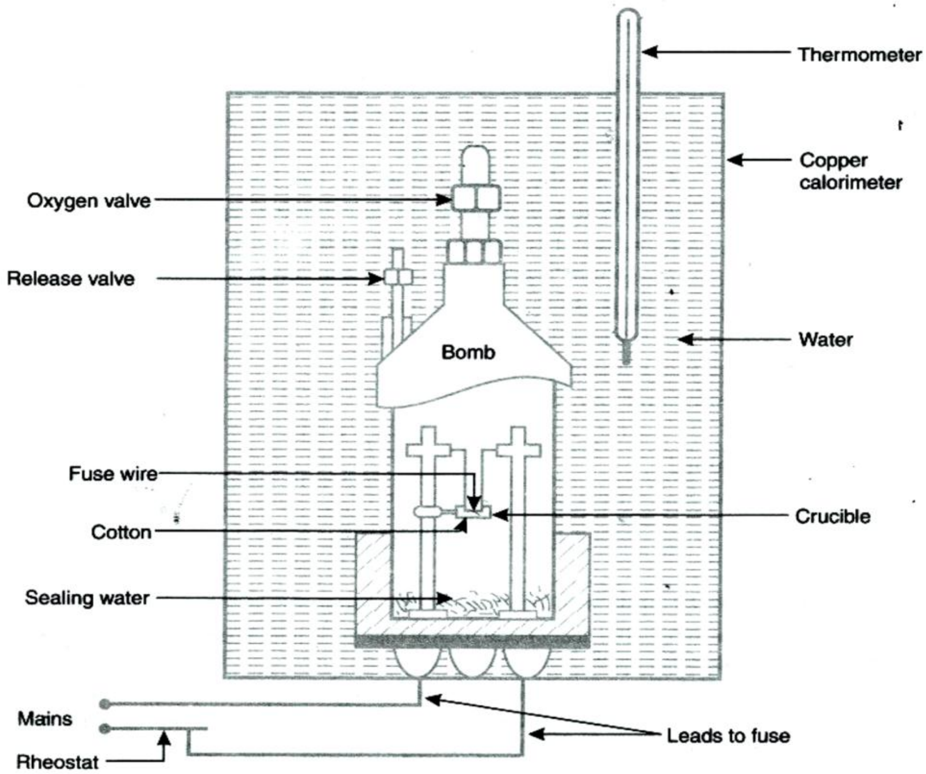
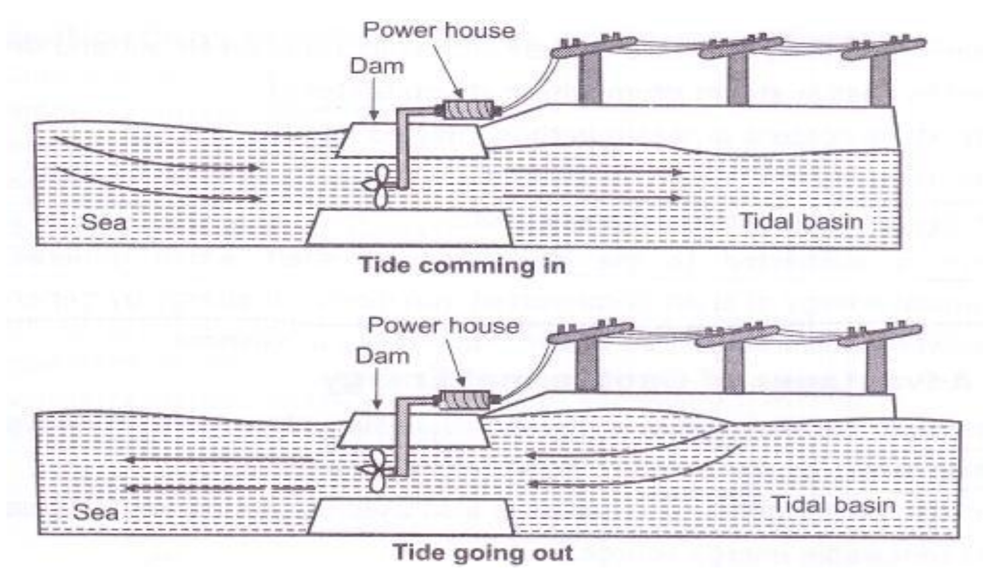
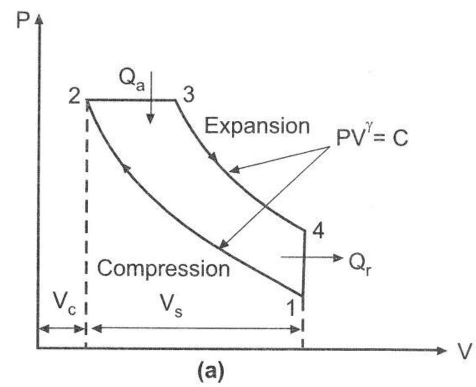
4	b	Describe with neat sketch construction and working of Bomb calorimeter. Write Dulong's formula and state its use.	08
	Ans.	Bomb calorimeter:  The calorific valve of solid and liquid fuels is determined in the laboratory by 'Bomb calorimeter' It is so named shape resembles that of bomb .Fig shows 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	04 02

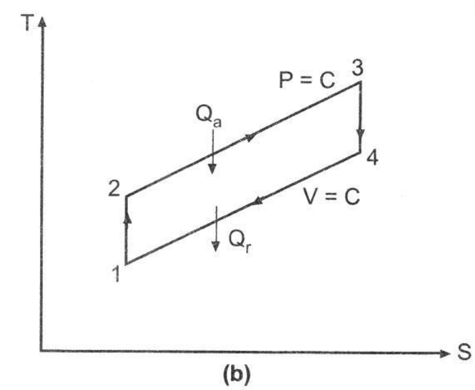
		temperature of water uniform and a thermometer the temperature up to accuracy of 0.0010 C is fitted through the lid of the calorimeter. The heat released by the fuel on combustion is absorbed by the surrounding water and the calorimeter. From the above data the calorific value of the fuel can be found. **Dulong's formula** used to calculate the theoretical calorific value of fuel if ultimate analysis is 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 Where C, H_2 O_2 & S repents the mass of carbon, hydrogen, oxygen and sulfur in kJ/Kg	02
4	C	Attempt the following:	08
4	C(i)	(i)Explain the tidal power plant.	04
	Ans.	**(i) Working of Tidal power plant:** During high tide the water flow from sea into the tidal basin through water turbine as the level of water in sea is more than tidal basin. This operates the turbine and generator and power is produced. Potential energy of sea water converted into mechanical energy by turbine and it converts into electrical by generators. During low tide water flow from tidal basin into sea as water level in the sea is lower than basin level in both cases generation of power is same. Only difference in that rotation of turbine blade is opposite. 	02 02

4	**C(ii)**	Explain H.C.V.and L.C.V. of fuels.	**04**
		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)	**02**
		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)	**02**
5		**Attempt any <u>TWO</u> of the following.**	**16**
	(a)	Derive the equation for air standard efficiency of diesel cycle.	**08**

Answer:



P - V diagram



T-S diagram

01

Diesel cycle consist of following four processes-
Process 1-2 : Isentropic compression
Process 2-3 : Heat addition at constant pressure
Process 3-4 : Isentropic expansion
Process 4-1 : Heat rejection at constant volume

01

Here compression ratio (r) = $\frac{V_1}{V_2}$

Cut- off ratio (ρ) =$\frac{V_3}{V_2}$

By considering 1 kg of air,

		Heat supplied = $Q_a = C_p (T_3 – T_2)$ Heat rejected = $Q_r = C_v (T_4 – T_1)$ Work done = $Q_a - Q_r$ $= C_p (T_3 – T_2) - C_v (T_4 – T_1)$	01
		Air standard efficiency is given by, $\eta_{ase} = \frac{Net\ work\ done}{Heat\ addition}$ $= \frac{C_p(T_3-T_2)-C_v(T_4-T_1)}{C_p(T_3-T_2)}$ $= 1 - \frac{T_4-T_1}{\frac{C_P}{C_V}(T_3-T_2)}$ $\eta_{ase} = 1 - \frac{T_4-T_1}{\gamma(T_3-T_2)}$ -------------------------------- (1)	01
		Consider isentropic process 1-2, $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$ $T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{\gamma-1} = T_1(r)^{\gamma-1}$	01
		Consider constant pressure heat addition process 2-3, As per Charle's law, $\frac{V}{T} = C$ $\frac{V_2}{T_2} = \frac{V_3}{T_3}$ $T_3 = \frac{V_3}{V_2} \times T_2 = \rho X\ T_2$	
		Consider isentropic process 3-4, $\frac{T_4}{T_3} = \left(\frac{V_3}{V_4}\right)^{\gamma-1}$	01

		$T_4 = T_3 \left(\frac{V_3}{V_2}\ X\ \frac{V_2}{V_4}\right)^{\gamma-1}$ $T_4 = T_3 \left(\frac{\rho}{r}\right)^{\gamma-1}$ $T_4 = \rho\ X\ T_1 (r)^{\gamma-1} \left(\frac{\rho}{r}\right)^{\gamma-1} = T_1\ \rho^{\gamma}$ Substituting the value of T_2, T_3 and T_4 in equation 1, $\eta_{ase} = 1 - \frac{T_4 - T_1}{\gamma(T_3 - T_2)}$ $\eta_{ase} = 1 - \frac{1}{\gamma}\left[\frac{T_1\rho^{\gamma} - T_1}{\rho_{T_1}(r)^{\gamma-1} - T_1(r)^{\gamma-1}}\right]$ $= 1 - \frac{1}{\gamma}\left[\frac{T_1(\rho^{\gamma}-1)}{T_1(r)^{\gamma-1}(\rho-1)}\right]$ $\eta_{ase} = 1 - \frac{1}{(r)^{\gamma-1}}\left[\frac{(\rho^{\gamma}-1)}{\gamma(\rho-1)}\right]$	02
5	(b)	Determine the quantity of heat required to produce 1 kg of steam at a pressure of 6 bar at a temperature of 25^0 C, under the following conditions: i) When steam is the wet having a dryness fraction 0.9. ii) When steam is dry saturated. iii)When it is superheated at a constant pressure at 250^0C. (Take Cp = 2.3 KJ/kgK For P = 6 bar, hf = 670.4 KJ/kg, and hfg = 2085 KJ/kg and t = 158.8^0C	08
		Answer: **Given:** P = 6 bar x = 0.9 $\triangle_T = 25^0$C C_{pw} = 4.187 KJ/kgK C_{psup} = 2.3 KJ/kgK $T_{sup} = 250^0$C $T_{sat} = 158.8^0$C m= 1 Kg From steam table, At 6 bar h_f = 670.4 KJ/kg, and h_{fg} = 2085 KJ/kg i) **Wet steam** $h_{wet} = h_f + x.\ h_{fg}$ =670.4 + 0.9 X 2085	

		h_{wet} = 2546.9 KJ/kg Heat already present in water =m C_{pw} $\triangle T$ = 1 X 4.187 X 25 = **104.675 KJ/Kg** Heat required per Kg of steam = h_{wet} - Heat already present in water = 2546.9 – 104.675 =**2442.225 KJ/Kg or KJ** ii) **Dry saturated steam** $h_g = h_f + h_{fg}$ = 670.4 + 2085 h_g = **2755.4 KJ/kg** Heat required per Kg of steam = h_g - Heat already present in water = 2755.4 – 104.675 =**2650.725 KJ/Kg or KJ** iii) **Superheated steam** $h_{sup} = h_f + h_{fg} + m\ C_{psup} (T_{sup} – T_{sat})$ = 670.4 + 2085 + 1 X 2.3 X (250 – 158.8) h_{sup} = **2965.16 KJ/Kg** Heat required per Kg of steam = h_{sup} - Heat already present in water = 2965.16 – 104.675 =**2860.485 KJ/Kg or KJ**	01 01 01 01 01 02 01
	(c)	Explain construction and working of screw compressor. Differentiate between centrifugal and axial flow compressor.	08
		Answer: Note- credit should be given to equivalent figure. **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.	01 01

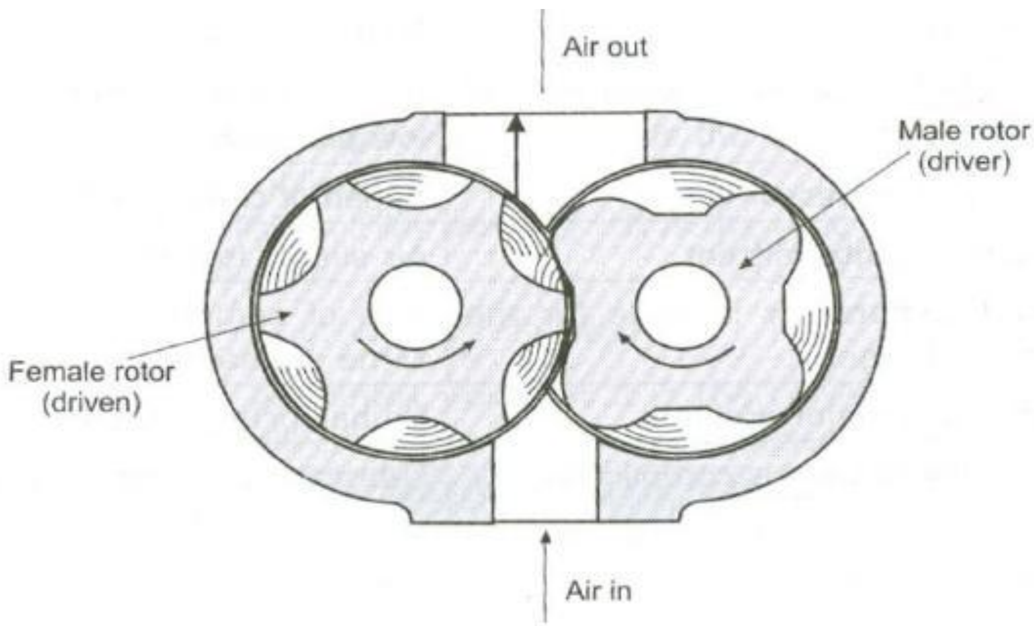


Fig. Screw Compressor

02

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

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

04

MODEL ANSWER

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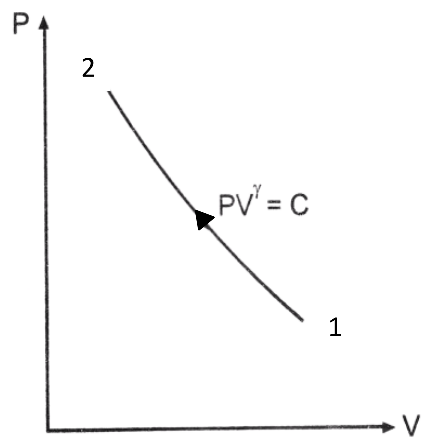
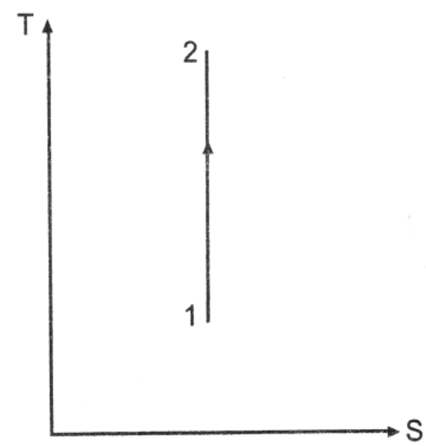
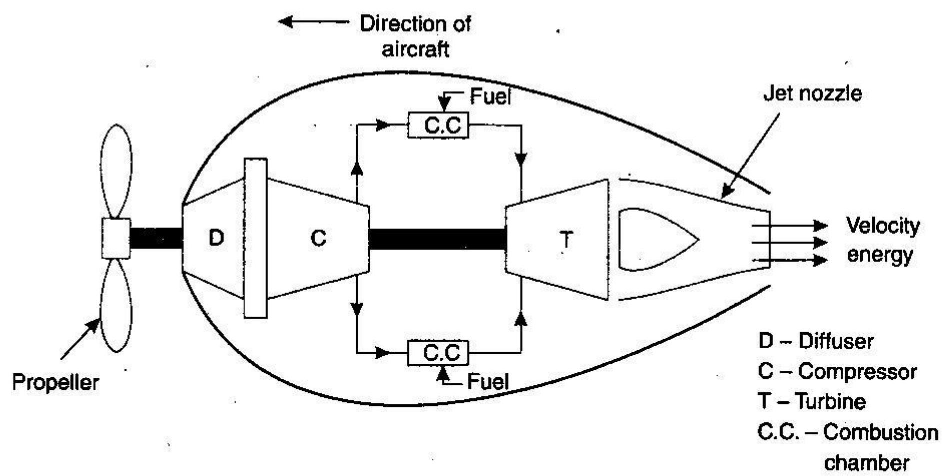
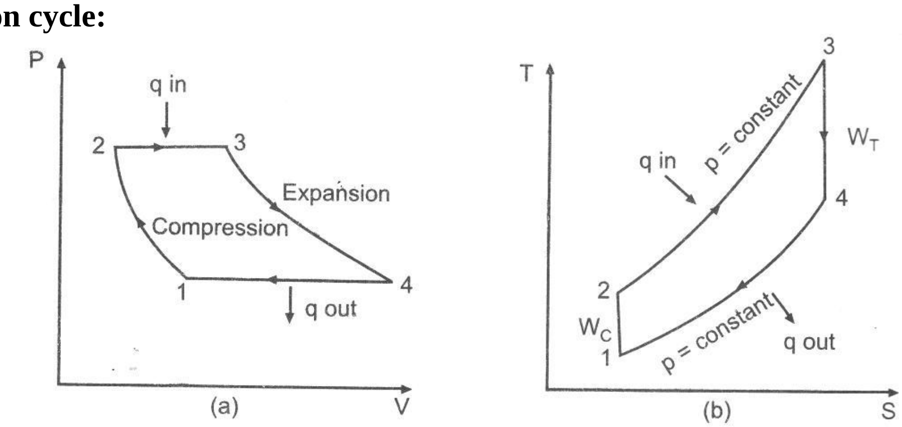
6.		**Attempt any FOUR of the following.**	**16**
6	**(a)**	Explain the adiabatic process with help of P-V & T-S diagram.	**04**
	Ans.	**Answer:- Explanation- 01 mark, Figure- 03 mark** **Adiabatic Process: The process in which heat is constant is known as adiabatic process.** **For adiabatic process, law is $PV^{\gamma} = C$.** **Where γ = Adiabatic index = Cp/Cv.**  P-V Diagram  T-S Diagram	**01** **03**
6	(b)	Explain sources of air leakage in condenser and define condenser efficiency.	**04**
		Answer:- **Sources of air leakage in condenser (any three)-** 1. Leakage from atmosphere at various joints of parts. 2. Air also comes in condenser with the steam. 3. In jet condensers dissolved air with injection water enters into the condenser. 4.Air leaks if any bypass seal is broken. **Condenser efficiency-** It is defined as ratio of difference between outlet and inlet temperature of cooling water to the difference between saturation temperature and inlet temperature of cooling water. or It is defined as ratio of rise in temperature of cooling water to the difference between saturation temperature and inlet temperature of cooling water.	**03** **01**
6	(c)	Enlist factors affecting volumetric efficiency of reciprocating air compressor.	**04**
		Answer: Factors affecting volumetric efficiency of reciprocating air compressor *(any four)*: 1) Clearance Volume 2) leakages at valves 3) Speed of compressor	**01 Mark each**

		4) Piston ring leakages 5) Temperature inside the cylinder 6) Expansion of fresh air by contact with hot wall.	
6	(d)	Explain construction and working of turbo-prop engine.	**04**
		Answer: Figure-02 marks, Construction and working- 02 marks  **Figure: Turbo- Prop Engine** **Construction and working:** It consist of diffuser, compressor, combustion chamber, turbine, nozzle and propeller. 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 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 velocity) into pressure energy by diffuser.	**02** **02**
6	(e)	Draw Brayton cycle on P.V and T-S diagram and write equation of thermal efficiency.	**04**
		Answer: Figure- 03 mark, Equation- 01 mark **Brayton cycle:**  P-V Diagram T-S Diagram	**03**

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		Equation of thermal efficiency (any one): $\eta_{th} = 1 - \frac{T1}{T2}$ **or** $\eta_{th} = \frac{T2-T1}{T2}$ **or** $\eta_{th} = 1 - \frac{1}{(r_p)^{\frac{\gamma-1}{\gamma}}}$	**01**
6	f	What is multi-staging? State necessity of multi-staging and intercooling of compressors.	**04**
	Ans.	**Answer:** **Multi-staging –** For producing high pressure two or more cylinders are provided in series with inter-cooling arrangement between them. Such an arrangement is known as multi-staging **Necessity of multistaging –** For producing high pressure i.e. more than 8 bar, single stage air compressor suffers fallowing drawbacks- i) Size of cylinder is too large ii) Rise in temperature of air is very high. To avoid this difficulty multi-staging is necessary. **Necessity of intercooling –** In two stage air compressor air is compressed in first cylinder and the temperature of air is increased. If this high temperature air is not passed through intercooler and sent directly to second stage then because of high temperature volume of air increases so amount of air taken inside decreases and pressure is also automatically decreased and volumetric efficiency is also decreases. To avoid this intercooling is necessary.	**01** **01** **02**