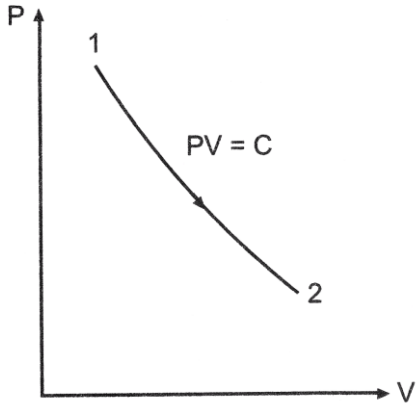
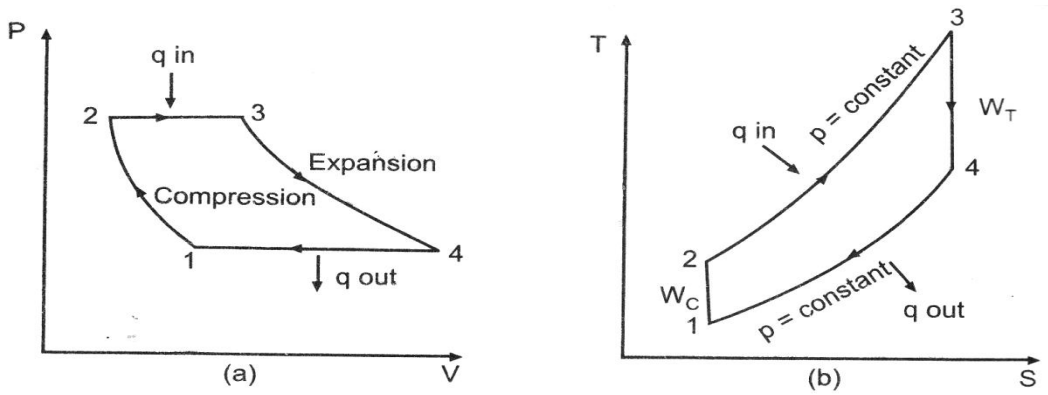
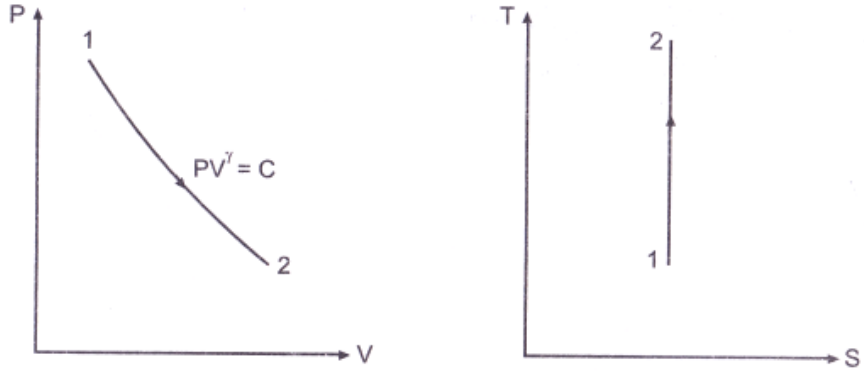
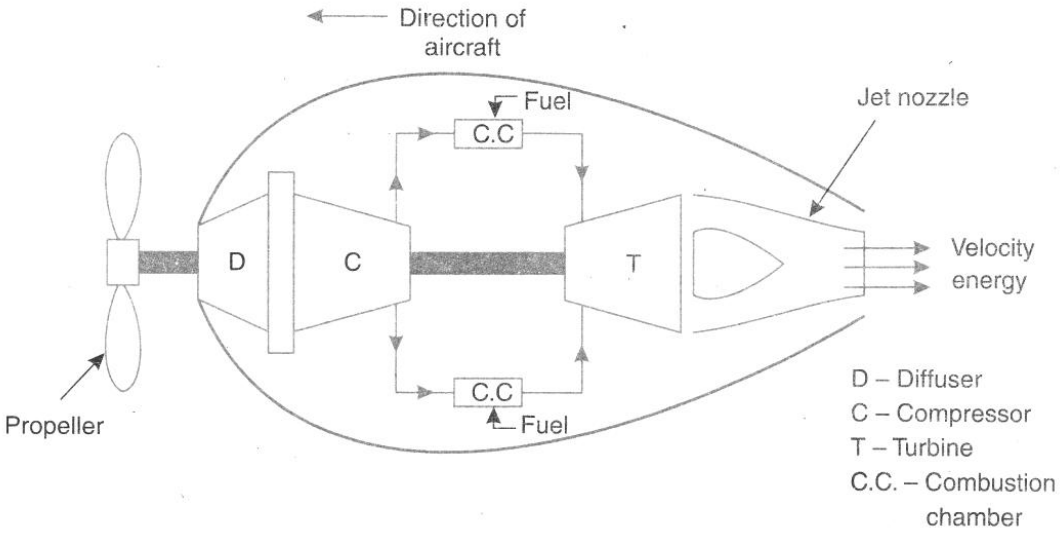
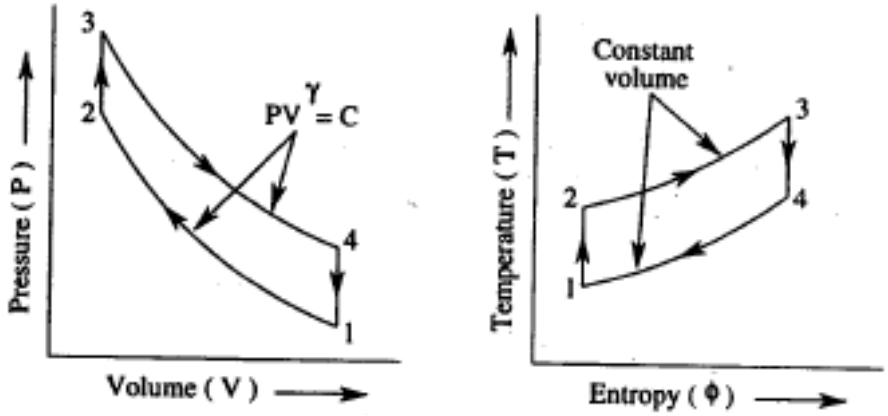
Important Instructions to examiners:

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.

1. A) Attempt **any SIX** of the following :	12
a) What is an isothermal process? Plot it on P-V diagram.	02
Answer: **Isothermal Process:** It is a Thermodynamic process in which temperature remains constant.  	01 01
b) Define sensible heat and latent heat.	02
Answer: **Sensible heat**: It is defined as the quantity of heat, during transfer of this heat, phase of substance will remain same & it can sense with the help of thermometer. **Latent heat**: It is defined as the quantity of heat required for phase change of working substance at saturation temperature.	01 01

c) State necessity of multi-staging in air compressors.	02
Answer: **Necessity of multi-staging in air compressors:** 1) The large pressure ratio in single stage compression gives high discharged temperature of air, which produce adverse effect on the efficiency and performance of the system. 2) To get better performance and saving in work and less power required to drive the compressor, multi-staging with intercooling is necessary.	01 01
d) Define Free Air Delivered (FAD).	02
Answer: **Free Air Delivered (FAD):** It is the actual volume of air delivered by the compressor when reduced to NTP.	02
e) Draw Brayton cycle on P-V diagram and T-S diagram.	02
Answer:  **Fig. Brayton cycle on P-V and T-S diagram**	02
f) State advantages of non-conventional energy.	02
Answer: **Advantages of non-conventional energy:** *(Any two)* 1. They do not pollute the atmosphere. 2. They are available in large quantity. 3. They are well-suited for decentralised use. 4. Use non-conventional energy sources will give carbon credit to nation.	02
g) What is calorific value of fuel? What is high calorific value?	02
Answer: **"Calorific value" of fuel:** It is defined as the amount of heat liberated during complete combustion of 1 kg of fuel. It is expressed in terms of KJ/kg. **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.	01 01
h) List out the merits of liquid fuels over gaseous fuels.	02
Answer: Merits of liquid fuels over gaseous fuels: *(Any four)* 1. Required less space for storage. 2. Higher calorific value. 3. Easy control of consumption. 4. Easy handling & transportation 5. Absences of danger from spontaneous combustion.	02

1. B) Attempt **any TWO** of the following :	08
a) Explain the adiabatic process with the help of P-V and T-S diagram. Give work done, internal energy and heat transferred in it.	4
Answer: Adiabatic Process:  Figure: adiabatic process During adiabatic process, heat transfer through substance is zero. Therefore according to first law of thermodynamic for a process Heat transfer = internal energy + work done dq = du + dw For adiabatic process, dq = 0 $dw = du = \frac{p_1v_1 - p_2v_2}{\gamma - 1}$	02 01 01
b) Steam enters in engine at pressure of 12 bar with a 67^0 C of superheat. It is exhausted at a pressure of 0.15 bar & 0.95 dry. Find the drop in enthalpy of the steam.	4
Answer: At 12 bar Cp=2.1 kj/kgk $hg = 2275.4$ kj/kgk $(T_{Sup} - T_{sat}) = 67^0 C$ $h_1 = hg + c_p(T_{Sup} - T_{sat})$ $= 2775.4 + 2.1 \times 67$ $= 2916.1$ Kj/Kg At 0.15 bar $hf = 226$ kj/kgk $hfg = 2373.2$ kj/kgk $h_2 = h_f + x\, h_f g$ $h_2 = 226 + 0.95 \times 2373.2$ $h_2 = 2480.5$KJ/kg Change in enthalpy $= \Delta H = h_2 - h_1$ $\Delta H = 2916.1 - 2480.5$ $\Delta H = 435.56$ KJ/kg	1 1 1 1

c) Explain the working principle of Turboprop engine, with a neat sketch.	04
Answer: **Turboprop engine:** *(Note: Credit should be given to relevant figure)*  **Figure: Turbo Prop 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 velocity) into pressure energy by diffuser. This type of compression is known as "ram effect".	02 02
2. Attempt **any FOUR** of the following :	16
a) Represent the Otto cycle on P-V & T-S diagram and write equations for air standard efficiency for the cycle.	04
Answer: **Air standard efficiency of Otto Cycle:**  	03

Derivation for Air standard efficiency: — 01

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

Where, r = compression ratio

γ = specific heat ratio

b) Differentiate between conduction and convection with example. — 04

Answer: **Difference between Conduction and Convection:** — 04

Sr. No.	Conduction	Convection
01	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.
02	It occurs in solid	Generally It occurs in liquids & gases
03	It governs by Fourier's law of heat conduction.	It governs by Newton's law of Convection heat transfer.
04	Example: Heat flow from one end to other end of metal rod.	Example: Heat flow from boiler shell to water.

c) Only draw labeled diagram of La-Mont Boiler. — 04

Answer: **La-Mont Boiler:** — 04

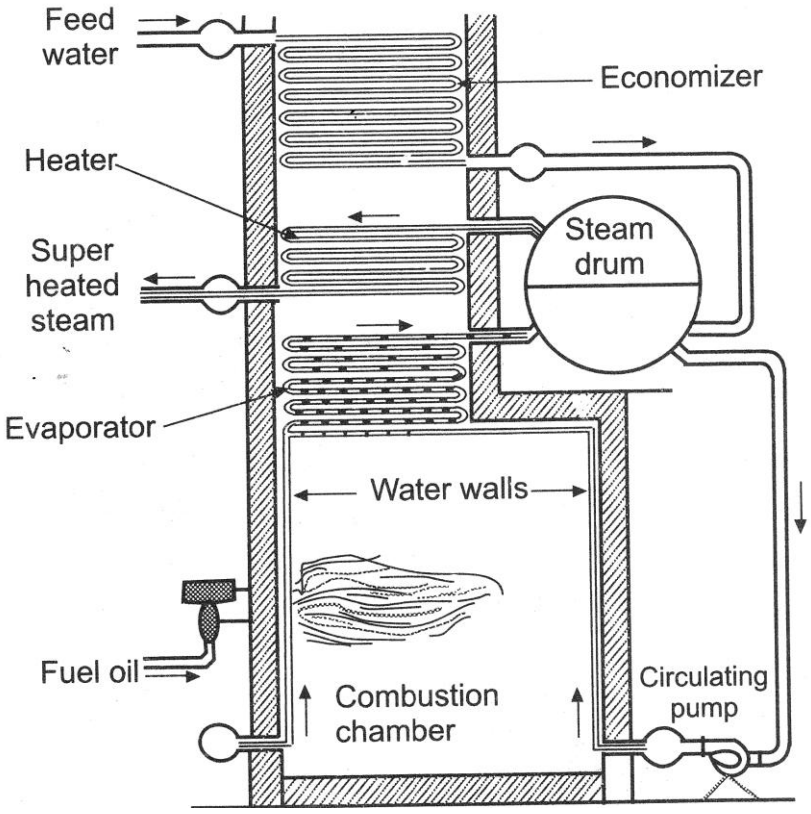
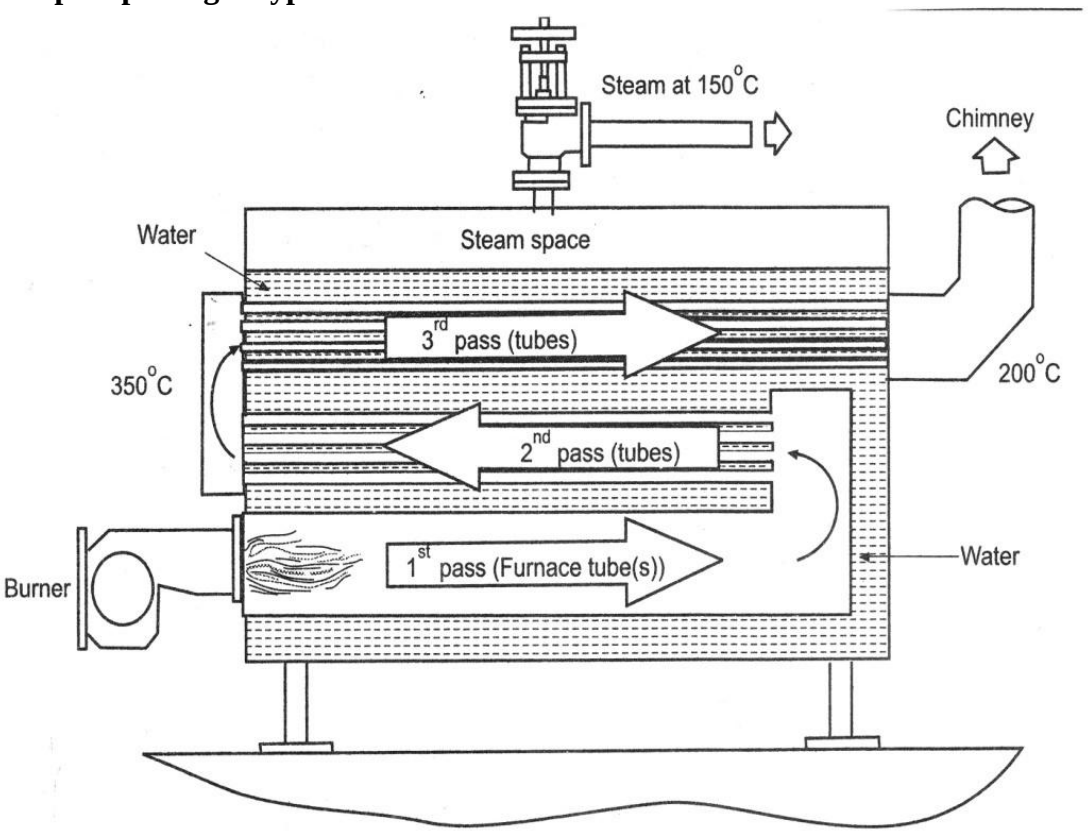
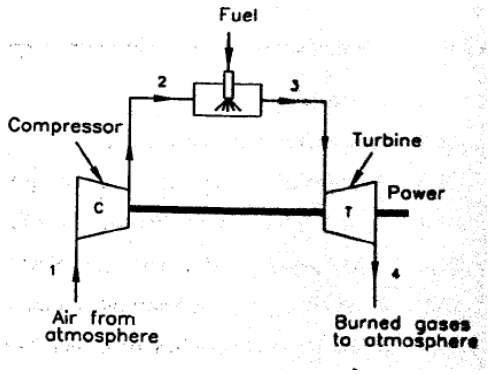
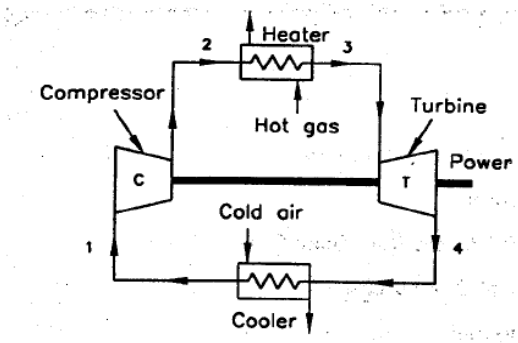


Fig : La Mont Boiler

d) Explain construction and working of three pass packaged type boiler.	04
Answer: **Three pass packaged type boiler:**  **Fig. Three pass packaged type boiler** **Construction:** The packaged boiler is so called because it comes as a complete package with burner, level controls, feed pump and all necessary boiler fittings and mountings. Once delivered to site it requires only the steam, water, and blowdown pipework, fuel supply and electrical connections to be made for it to become operational. This type of boiler having capacity of 50 ton per hour. It consists of three stages of tube in which flue gases are flowing. It has maximum structural rigidity and safety. Presently these types of boilers are also designed to burn wood, coal and process waste also. **Working:** In this boiler pulverized coal is used as a fuel. Hot gases are produced by burning coal and these gases are passed through three stages of tubes. Tubes are surrounded by water & heat is transfer from hot flue gases to water through tubes & water converted first in to vapour & finally in to steam.	02 1 1
e) State various factors affecting volumetric efficiency of air compressor.	04
Answer: **Factors affecting volumetric efficiency of air compressor:** *(Any four)* 1. Very high speed. 2. Leakage past the piston. 3. Obstruction at inlet valves. 4. Overheating of air by contact with hot cylinder wall. 5. Inertia effect of air in suction pipe.	04

f) Compare open cycle gas turbine and closed cycle turbine. — 04

Answer: **Comparison of open cycle and closed cycle gas turbine:***(Any four)* — 04

Sr. No.	Open cycle gas turbine	Closed cycle gas turbine
1.		
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.

3. Attempt **any FOUR** of the following: — 16

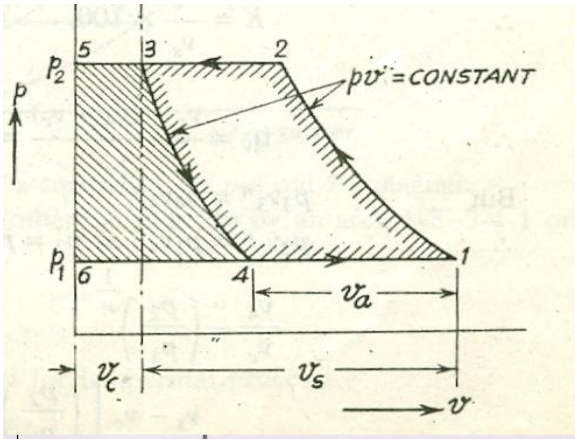
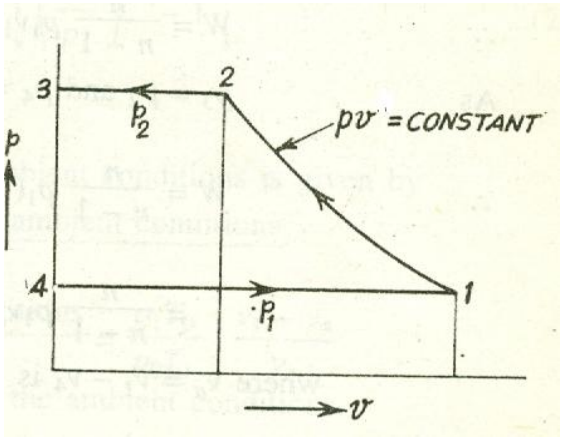
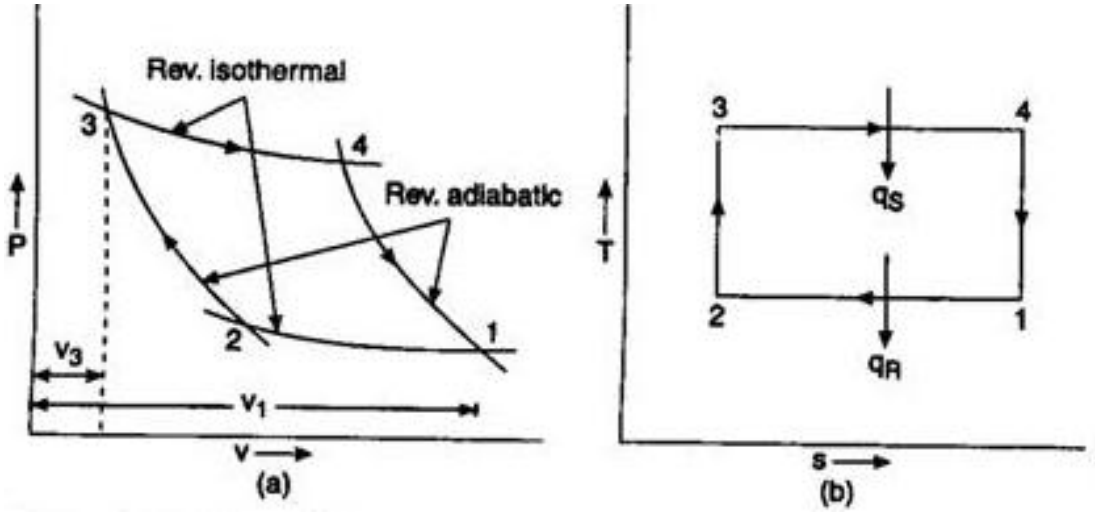
a) Explain working of single stage reciprocating air compressor with the help of P-V diagram. — 04

Answer: **Working of Single stage reciprocating air compressor:**

A reciprocating compressor consists of a cylinder, piston, inlet and outlet valves.

During downward motion of piston, the pressure inside the cylinder falls below the atmospheric pressure and inlet valve is opened due to the pressure difference. The air is taken into the cylinder until the piston reaches bottom dead centre position.

As the piston starts moving upwards, the inlet valve closed and pressure starts increasing continuously until the pressure inside the cylinder is above the pressure of the delivery side which is connected to the receiver. At the end of delivery stroke small volume of high pressure air is left in the clearance space. The high pressure air left in the clearance space expands as the piston starts moving downwards and pressure of air falls until it is just below the atmospheric pressure. The inlet valve opens as the pressure inside the cylinder falls below the atmospheric pressure and the air from outside is taken in and the cycle is repeated. — 2

The P-V diagram for single stage and single acting reciprocating air compressor with clearance and without clearance is as follows:  	2
b) Plot Carnot cycle on P-V and T-S diagram.	04
Answer:  Figure: Carnot cycle P-V and T-S diagram	04
c) Point out parameters involved in site selection of Diesel power plant.	04
Answer: **Parameters involved in the site selection for the Diesel Power Plant:** ***(any four)*** 1. Availability of raw material 2. Nature of land 3. Cost of land 4. Availability of water 5. Transport facilities 6. Availability of labour.	4
d) Only draw a neat sketch of Thermal Power Plant.	4

Answer: **Thermal power plant:** *(Credit shall be given to any other appropriate sketch)* — 4

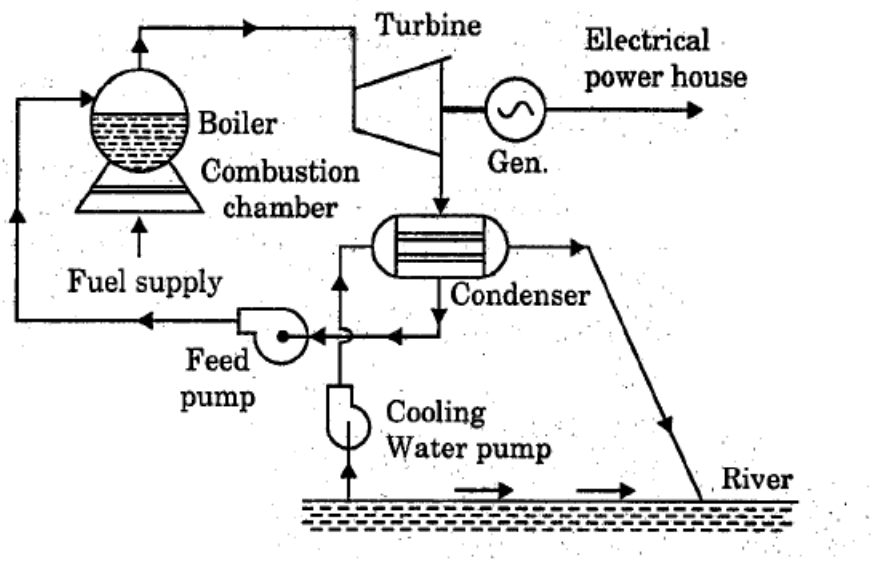


Fig : Thermal Power Plant

e) Write four advantages of liquid fuels over gaseous fuels used in boilers. — 04

Answer: **Advantages of liquid fuels over gaseous fuels used in boilers:** *(Any four)* — 4

1. Required less space for storage.
2. Higher calorific value.
3. Easy control of consumption.
4. Easy handling & transportation
5. Absences of danger from spontaneous combustion.

f) A steam boiler uses pulverized coal in the furnace. The ultimate analysis of coal (by mass) as received is: — 04

C = 78%; H_2 = 3%; O_2 = 3%;S = 1%; Ash = 10% and Moisture = 5% Excess air supplied is 30 %.Calculate the mass of air to be supplied and mass of gaseous product formed per kg of coal burnt.

Answer: Given:

C = 78% =0.78kg, O_2 = 3%=0.03kg, S = 1%=0.01kg, Ash = 10%=0.1kg

Moisture = 5%=0.05kg, Excess air supplied is 30 %

Solution:

i) Mass of air to be supplied per kg of coal burnt:

We know that theoretical air required burning 1 Kg of coal

$$= \frac{100}{23}\left[\left(\frac{8}{3}C + 8H_2 + S\right) - O_2\right] \text{kg}$$

$$= \frac{100}{23}\left[\left(\frac{8}{3}\times 0.78 + 8\times 0.03 + 0.01\right) - 0.03\right] = 10.1\text{kg}$$

$\therefore$ Excess air supplied per kg of coal

$$= \frac{30\times 10.1}{100} = 3.03\text{kg}$$

And mass of air to be supplied per kg coal burnt

$$= \text{Therotical air} + \text{Excess air}$$
$$= 10.1 + 3.03 = 13.13\,\text{kg}$$

— 2

ii) Mass of gaseous products formed per kg of coal:

The gaseous products formed are carbon dioxide (CO_2) water (H_2O), sulphur dioxide (SO_2), excess oxygen (O_2),and nitrogen (N_2),we know that 1 kg of carbon produces 11/3 kg of carbon dioxide 1 kg of hydrogen produces 9kg of water and 1 kg of sulphur produces 2 kg of sulphur dioxide .

$\therefore$ Mass of (CO_2) Produced per kg of coal

$$= \frac{11}{3} \times 0.78 = 2.86 \text{ kg}$$

Mass of (H_2O) Produced per kg of coal

$$= 9 \times 0.03 = 0.27 \text{ kg}$$

Mass of (SO_2) Produced per kg of coal

$$= 2 \times 0.01 = 0.02 \text{ kg}$$

Mass of excess (O_2) Produced per kg of coal

$$= \frac{23}{100} \times \text{Excess Air Supplied} = \frac{23}{100} \times 0.03 = 0.70kg$$

Mass of (N_2) per kg of coal

$$= \frac{77}{100} \times \text{Actual Mass of air suppiled} = \frac{77}{100} \times 13.13 = 10.1 \text{ kg}$$

2

4. A) Attempt **any TWO** of the following. 16

a) Compare conventional energy sources and non- conventional energy sources on the basis of 08
   i) Availability
   ii) Harnessing Technology Developed
   iii) Harnessing cost
   iv) pollution
   v) Magnitude of power generation.

Answer: **Comparison of conventional energy sources and non- conventional energy sources:**

Parameters	**Conventional Energy sources**	**Non Conventional Energy sources**
i) Availability	Less available (Non Renewable)	Available in large quantity (Renewable)
ii) Harnessing Technology Developed	Developed	It has more scope to develop.
iii) Harnessing Cost	Less	High
iv) Pollution	Causes environmental pollution	Does not Cause environmental pollution
v) Magnitude of Power Generation	High	Low

08

b) Compare : 8
   i) Solid Fuels and Gaseous Fuel
   ii) Ultimate Analysis and Proximate Analysis.

Answer: i) **Comparison of Solid Fuels and Gaseous Fuel:** *(any four)* — 04

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

ii) Compare ultimate analysis and proximate analysis (2 marks for each) — 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.

c)Attempt the following: — 8

i) Explain the working of geothermal power plant with a neat sketch.

ii) Explain the working of Tidal power plant with a neat sketch.

Answer: i) **Working of geothermal power plant**: — 02

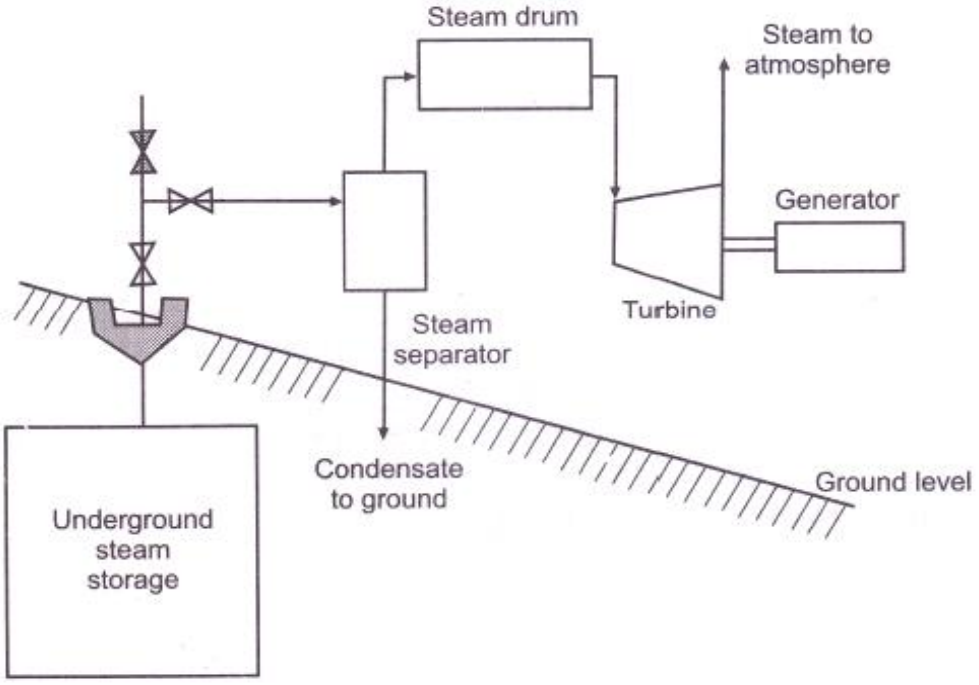


Figure: Geothermal power plant

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 200^0 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) 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. — 02

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

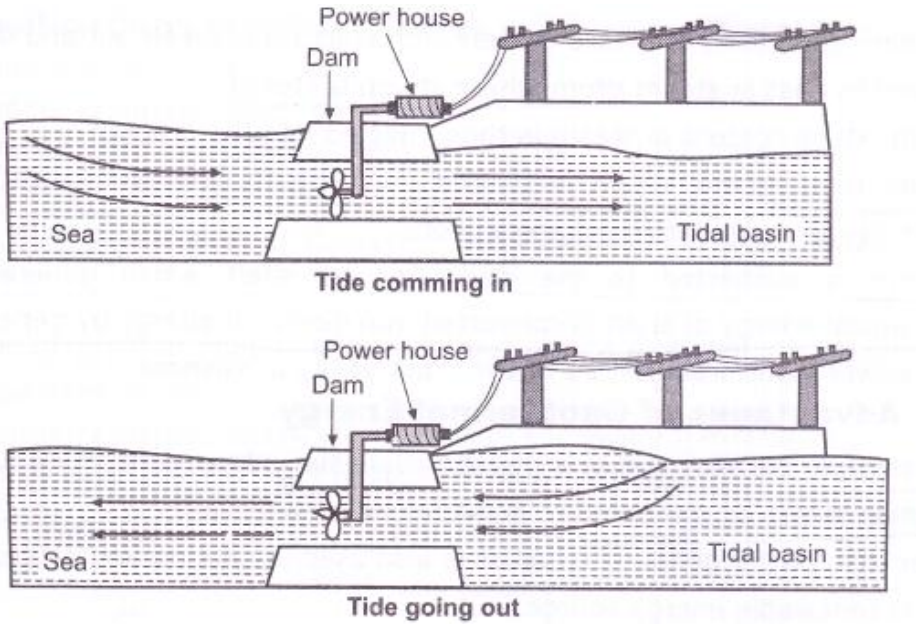


Figure: Tidal power plant

5. Attempt **any TWO** of the following **:** — 16

a) Derive the relation between P, V and T during Adiabatic Process. — 08

Answer: **Relation between P, V and T during Adiabatic Process:**

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

For adiabatic Process,

$$PV^{\gamma} = C$$

$$P_1 v_1^{\gamma} = P_2 v_2^{\gamma} \quad \text{— 01}$$

$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma} \quad \ldots\ldots\ldots\ldots\ldots (1) \quad \text{— 01}$$

From general gas equation

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

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

01

$$\frac{T_2}{T_1} = \frac{P_2V_2}{P_1V_1} \quad \text{.....(2)}$$

01

From (1)

$$\frac{V_2}{V_1} = \left(\frac{P_1}{P_2}\right)^{1/\gamma} \text{..... (3)}$$

01

Put equation (3) into equation (2)

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

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

$$\frac{P_2}{P_1} = \left(\frac{T_2}{T_1}\right)^{\frac{\gamma}{\gamma-1}} \text{.....(4)}$$

01

From equation (1) & (4)

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

01

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

01

b) i) What are the various sources of air leakage into a steam condenser? How does it affect the performance of the condensing plant? 8
ii) Explain the function and location of condenser in steam power plant.

Answer: **i) Sources of air leakage in condenser:**

1. Air leak through joints and packing.
2. Air also comes in condenser with the steam.
3. In jet condensers dissolved air in the cooling water enters the condenser.

02

Effects:

1. Lowered the thermal efficiency.
2. Increased requirement of cooling water.
3. Reduced heat transfer.
4. Increased Corrosion.

02

ii) Function and location of condenser in steam power plant:

Function: 1. It is a device which condenses steam by heat release from steam with help of water
2. It maintains very low back pressure thus more work can be obtained.
3. Temperature of condensate is more than of feed water so amount of heat supplied per kg of steam is reduced.

03

Location: It locates in between Turbine and Feed pump.

01

c) Explain the construction & working of screw compressor. Differentiate between centrifugal and axial flow compressor.

Answer: **Screw compressor:**

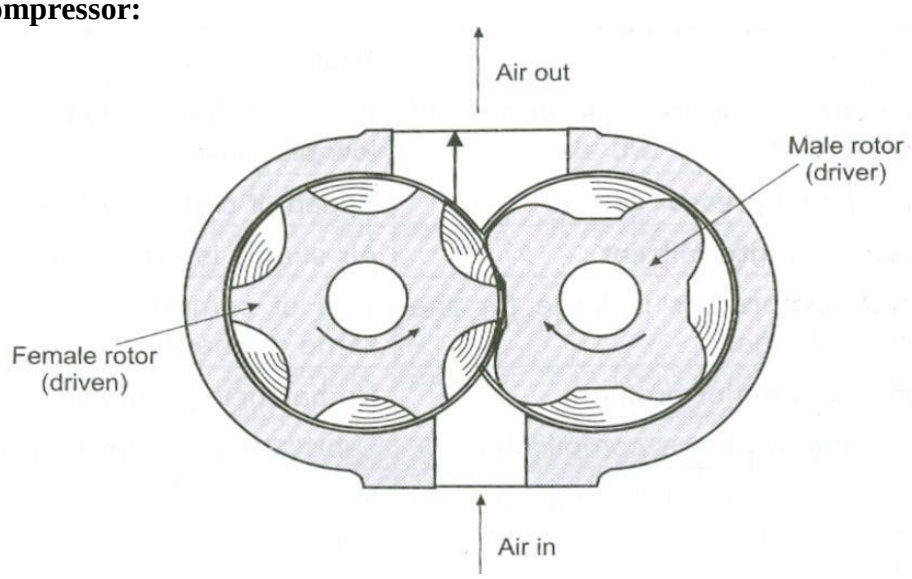


Fig. Screw Compressor

Construction and Working:

- 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.
- 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 I operation. Used in refrigeration industry.

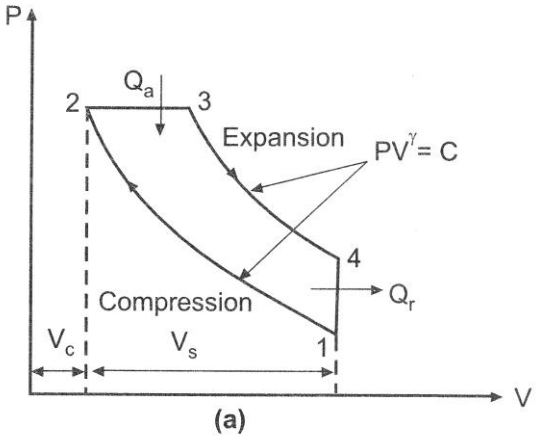
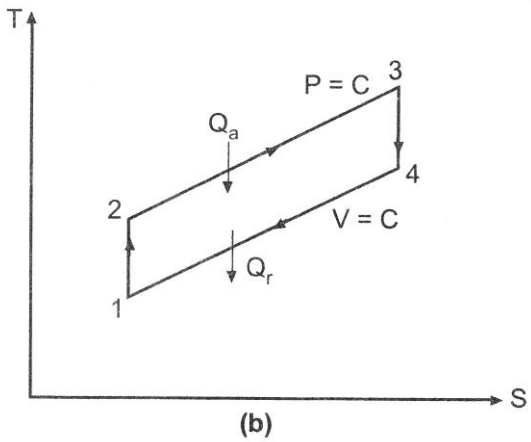
Difference between Centrifugal and Axial flow compressor.*(Any Four)*

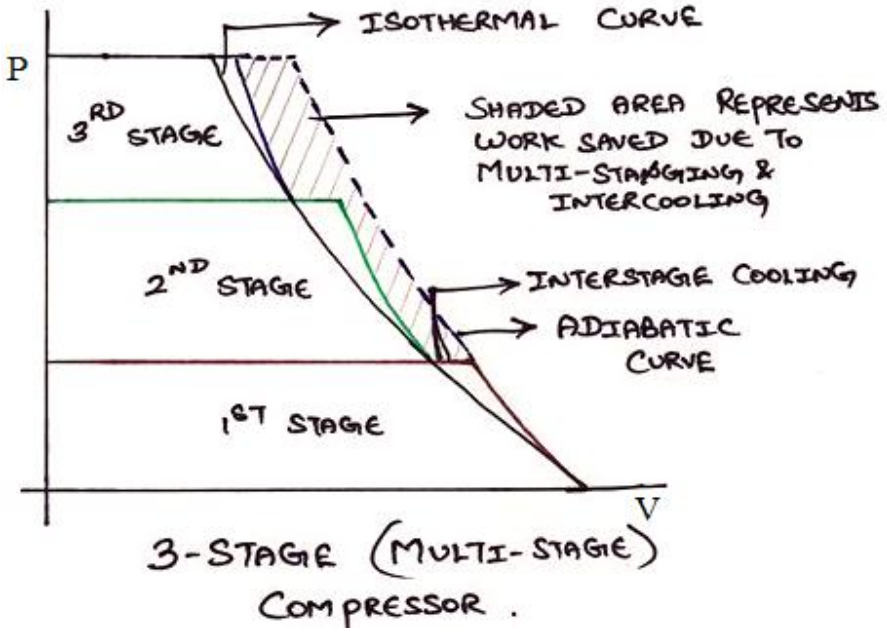
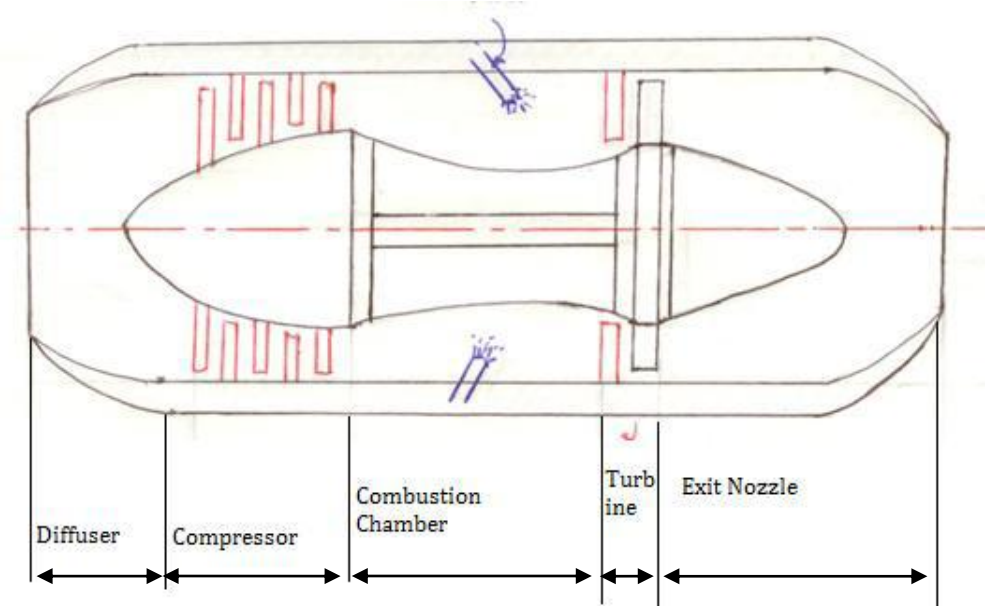
Sr. No.	Centrifugal compressor	Axial Flow Compressor
1	Flow is perpendicular to axis of compressor.	Flow of air is parallel to the axis of compressor.
2	Low manufacturing and running cost.	High manufacturing and running cost.
3	Requires low starting torque.	Requires high starting torque.
4	Not suitable for multi-staging.	Suitable for multi-staging.
5	Requires large frontal area for given rate of flow.	Requires less frontal area for given rate of flow.
6	Pressure ratio per stage is4:1.	Pressure ratio is 1.1 to 1.2
7	Isentropic efficiency is 70%	Isentropic efficiency is 80%
8	Used in supercharging I.C. engine and for refrigerants and industrial gases.	Used universally with large gas turbine.

02

02

04

6. Attempt any FOUR:	16
a) Explain briefly Diesel Cycle with the help of P-V and T-S diagram and write equation of Air Standard Efficiency of Diesel cycle.	4
Answer : **Diesel cycle on P-V and T-S diagram:**   P - V diagram T-S diagram Diesel cycle is the ideal model for the compression-ignition engine (Diesel engine). This air-standard Diesel cycle is composed of four processes: 4-1: isentropic compression 1-2: Constant pressure heat addition 2-3: isentropic expansion 3-4: Constant volume heat rejection **Equation for efficiency for diesel cycle:** $\eta = 1 - \frac{1}{(r)^{\gamma-1}} \left[\frac{\rho^\gamma - 1}{\gamma(\rho-1)}\right]$	02 01 01
b) Give classification of condensers.	04
Answer: **Classification of condensers:** Condensers are mainly classified into two types , 1.Jet Condenser a. Parallel flow type b. Counter flow type c. Ejector type 2.Surface Condenser a. Down flow type b. Central flow type c. Regenerative type d. Evaporative type	02 02

c) What are the advantages of multi-stage compression? Explain it on P-V diagram.	04
Answer: **Advantages of multi-stage compression:-** *(Any four)* 1. Reduces power required to drive the compressor 2. Gives better volumetric efficiency 3. Work required per kg of air is reduced 4. Gives more uniform torque hence smaller size of flywheel is required 5. It reduces leakage loss 6. It reduces cost of compressor	02
 3-STAGE (MULTI-STAGE) COMPRESSOR .	02
d) Explain the construction and working of Turbojet engine.	4
Answer: **Turbo-jet Engine: Construction and working:**  **Fig. Turbo-jet Engine**	02

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.	02
e) Give advantages of closed gas turbine plant over open type gas turbine plant.	4
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
f) Give applications of compressed air.	04
Answer: **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	04