***MODEL ANSWER***

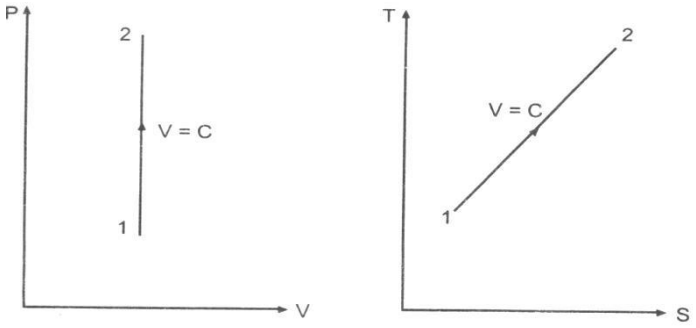
**WINTER– 18 EXAMINATION**

**Subject Title: HEAT POWER ENGINEERING**

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 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 |
|---|---|---|---|
| **01** | **A)** | **Attempt any SIX :** | **12** |
| | **a)** | **Draw P-V and T-S diagram for isochoric process.** | **02** |
| | | **Answer: Isochoric Process:**   | **( 01-Mark for each)** |
| | **b)** | **Define sensible and latent heat.** | **02** |
| | | **Answer:**<br><br>**Sensible heat**: It is defined as the quantity of heat which can be sensed by the thermometer.<br>OR<br>The amount of heat added up to saturation temperature is called sensible heat.<br><br>**Latent heat**: It is defined as the quantity of heat required for phase change of working substance at saturation temperature.<br>OR<br>The amount of heat added at saturation temperature is called latent heat. | **( 01-Mark for each)** |

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| | **c)** | **Define isothermal efficiency of compressor.** | **02** |
| | | **Answer**:<br>**Isothermal Efficiency of compressor:**<br>It is the ratio of isothermal work (or power) required to drive compressor to the actual work required to drive compressor for the same pressure ratio.<br><br>Mathematically isothermal efficiency is given as the ratio of isothermal power to shaft or brake power. | **02** |
| | **d)** | **State the uses of compressed air.** | **02** |
| | | **Answer:**<br>**Application of compressed air: (Any four)**<br>1. Operating tools in factories<br>2. Operating drills and hammers in road building<br>3. Starting diesel engines<br>4. Operating brakes on buses, trucks and trains<br>5. Spray painting<br>6. Excavating<br>7. To clean the large workshops Etc. | **½ Mark each** |
| | **e)** | State classification of gas turbine | **02** |
| | | **Answer:**<br>**Classification of gas turbine:** *(Any two)*<br>**1. According to the path of the working substance:**<br>i) Open cycle gas turbine<br>ii) Close cycle gas turbine<br>iii) Semi-closed cycle gas turbine<br><br>**2. According to process of combustion:**<br>i) Constant pressure gas turbine<br>ii) Constant volume gas turbine<br><br>**3. According to direction of flow:**<br>i) Radial flow<br>ii) Axial flow<br>iii) Tangential flow<br><br>4. **According to principle of action of expanding gases:**<br>i) Impulse turbine<br>ii) Reaction turbine<br><br>**5. According to their usage:**<br>i) Constant speed<br>ii) ii) Variable speed | 1 mark each |

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| | **f)** | **Enlist non-conventional energy sources.** | **02** |
| | | **Answer:**<br>**Non-conventional sources of energy: (Any FOUR)**<br>i) Solar energy<br>ii) Wind energy<br>iii) Geothermal energy<br>iv) Tidal energy<br>v) Biomass | **½ Mark each** |
| | **g)** | **List out merits of liquid fuel over solid fuel** | **02** |
| | | **Merits of liquid fuel over solid fuel: (any four)**<br>1. Require less space for storage.<br>2. Higher calorific value.<br>3. Easy control of consumption.<br>4. Cleanliness.<br>5. No ash produced.<br>6. Non-deterioration of the oil in storage. | **½ Mark each** |
| | **h)** | **State two advantages and disadvantages of LPG** | **02** |
| | | **Advantages of LPG: (any two-1/2 Mark each)**<br>1. LPG has a higher octane rating than petrol, hence can be used as an alternate fuel in cars.<br>2. It is a clean & complete burning environment friendly fuel.<br>3. It can be transported easily to remote places by road and also by rail.<br>4. flame temperature can instantly controllable<br>5. It is non toxic and non corrosive.<br>6. It does not pre-ignite easily.<br><br>**Disadvantages of LPG: (any two-1/2 Mark each)**<br>1. Highly inflammable.<br>2. It has to be stored in heavy steel container under high pressure up to10 bar.<br>3. It has low energy density.<br>4. It causes suffocation, in case of leakage as it is heavier than air.<br>5. Auto LPG's odor is faint, it cannot be easily detected in case of any leakage. | **½ Mark each** |

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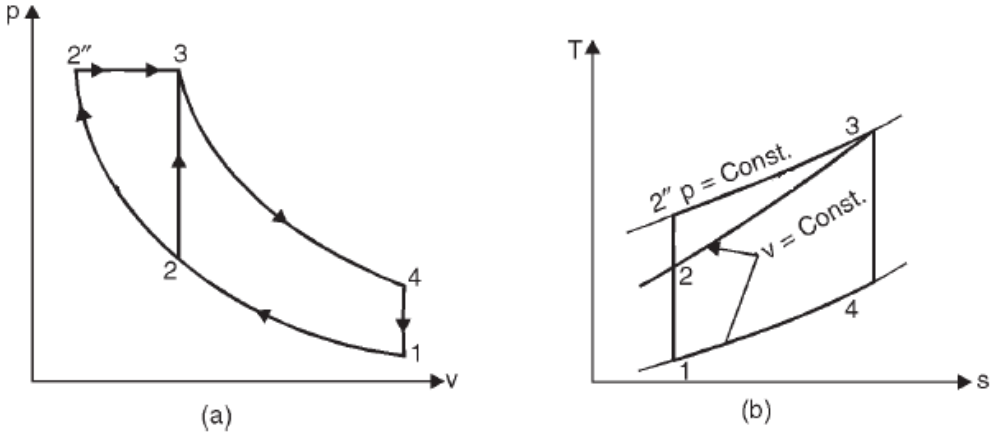
| 1 | **B** | **Attempt any <u>TWO</u> :** | **08** |
| | **a)** | State formulae for air standard efficiency of Otto cycle and Diesel cycle. Compare efficiency for same pressure ration and same conditions. Comment. | **04** |
| | | **Answer:**<br>**Equations of air standard efficiency of otto and diesel cycle:**<br>1) $\eta = 1 - \frac{1}{r^{\gamma-1}}$ ----------Equation of air standard efficiency for Otto cycle. **01**<br>2) $\eta = 1 - \frac{1}{(r)^{\gamma-1}}\left[\frac{\rho^{\gamma}-1}{\gamma(\rho-1)}\right]$------ Equation of air standard efficiency for diesel cycle. **01**<br>Where,<br>r = compression ratio<br>γ = Ratio of specific heat (Adiabatic constant)<br>ρ = Cut off ratio<br><br>Comparison of efficiency of Otto Cycle and Diesel cycle for same pressure ration and same conditions. **01**<br>  <br><br>The air-standard Otto and Diesel cycles are drawn on common *p-v* and *T-s* diagrams for the same pressure ratio and maximum temperature, for the purpose of comparison.<br><br>Otto Cycle 1-2-3-4-1 And Diesel Cycle 1-2”-3-4-1<br><br>The construction of cycles on *T-s* diagram proves that for the given conditions the heat rejected is same for all the Otto and Diesel cycles (area under process line 4-1).<br><br>Since, by definition,<br>$\eta = 1 - \frac{\text{Heat rejected, } Q_r}{\text{Heat supplied, } Q_s} = 1 - \frac{\text{Const.}}{Q_s}$<br>the cycle, with greater heat addition will be more efficient. From the *T-s* diagram, | |

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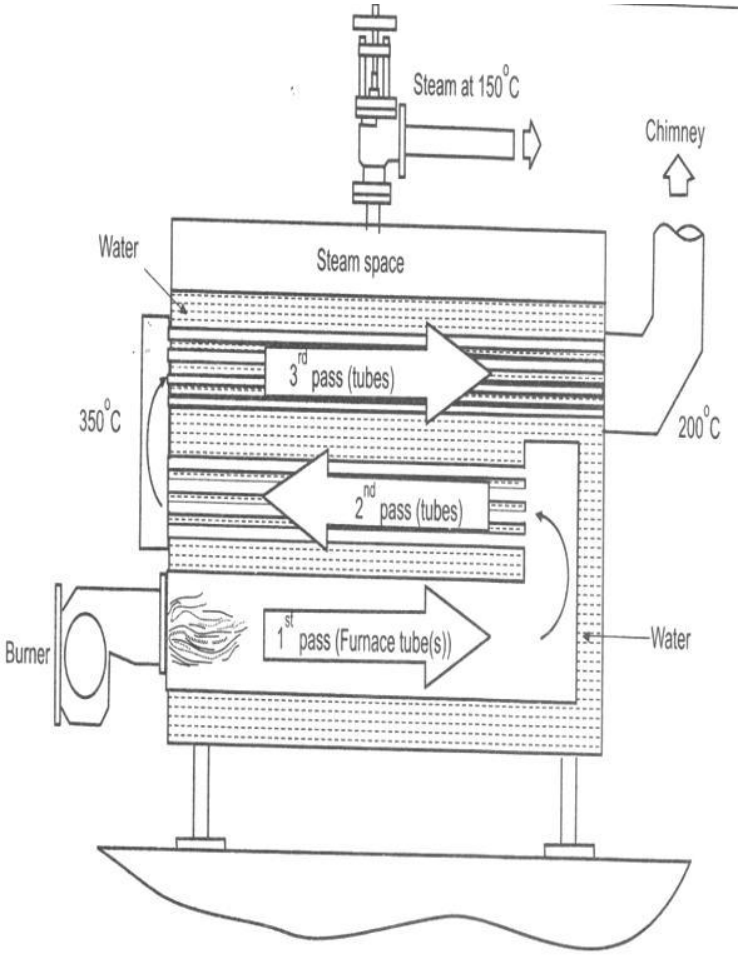
| | | $Q_{s(\text{diesel})}$ = Area under 2″-3<br>$Q_{s(\text{otto})}$ = Area under 2-3.<br>Therefore for same pressure ration,<br>It can be seen that, $Q_{s(\text{diesel})} > Q_{s(\text{otto})}$<br>and thus, $\eta_{\text{diesel}} > \eta_{\text{otto}}$. | **01** |
| | **b)** | **Draw a neat labelled sketch of three pass packaged type boiler.** | **04** |
| | | **Three pass packaged type boiler: (sketch 02 marks and Labelling 02 Marks)**<br>  <br><br>**Fig. Three pass packaged type boiler** | **04** |

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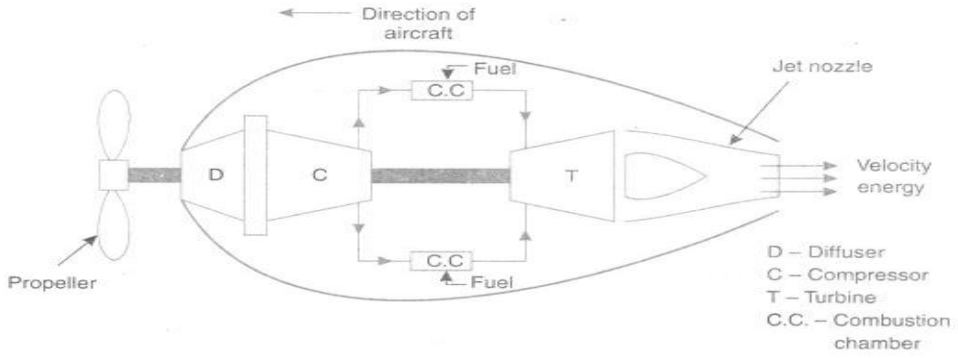
| | **c)** | **Explain working of turboprop engine.** | **04** |
| | | **Turboprop engine: (Note: Working: 2 marks and Diagram: 2 marks.)**<br>  <br><br>Fig : Turbo Prop Engine<br><br>**Working:** Figure shows a turboprop system employed in aircrafts. Here the expansion of gases takes place partly in 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**<br><br>**02** |
| **2** | | **Attempt any <u>FOUR</u> :** | **16** |
| | **a)** | **Explain with P-V and T-S diagram of diesel cycle.** | **04** |
| | | **Diesel cycle on P-V and T-S diagram:**<br>This cycle was introduced by Dr. R. Diesel in 1897. It differs from Otto cycle in that heat is supplied at constant pressure instead of at constant volume. Fig. a and b Shows the p-v and T-s diagrams of this cycle respectively. | |

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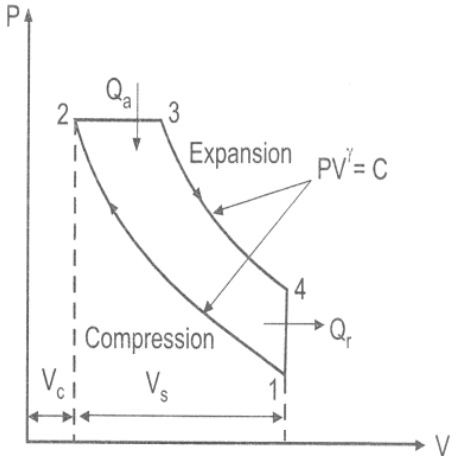
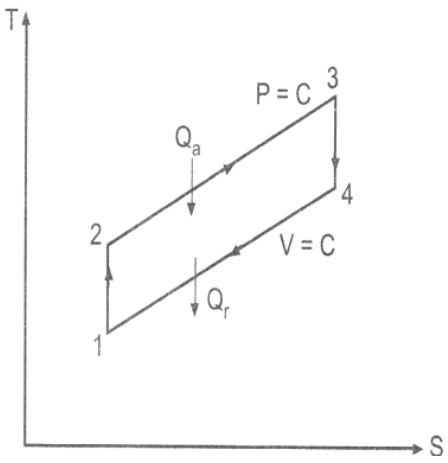
| | |   <br>Fig. (a) P-V diagram (Diesel cycle) Fig. (b) T-S diagram (Diesel cycle)<br><br>This cycle comprises of the following operations :<br>(i) 1-2.....Adiabatic compression.<br>(ii) 2-3.....Addition of heat at constant pressure.<br>(iii) 3-4.....Adiabatic expansion.<br>(iv) 4-1.....Rejection of heat at constant volume.<br>Point 1 represents that the cylinder is full of air.<br>Let p1, V1 and T1 be the corresponding pressure, volume and absolute temperature. The piston then compresses the air adiabatically (i.e., $pV^\gamma$ = constant) till the values become p2, V2 and T2 respectively (at the end of the stroke) at point 2. Heat is then added from a hot body at a constant pressure. During this addition of heat let volume increases from V2 to V3 and temperature T2 to T3, corresponding to point 3. This point (3) is called the point of cut-off. The air then expands adiabatically to the conditions p4, V4 and T4 respectively corresponding to point 4. Finally, the air rejects the heat to the cold body at constant volume till the point 1 where it returns to its original state. | **02**<br><br>**02** |
| | **b)** | **Explain process of heat transfer in automobiles.** | **04** |
| | | **Answer:**<br>**In automobile heat is transfer takes place in three modes as explained below:**<br>**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<br>**Example:-** Fins provided on motor cycle engine.<br><br>**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.<br>**Example:-** coolants get heated inside the radiator and engine jacket. | **1½**<br>**½**<br><br>**1½**<br>**½** |

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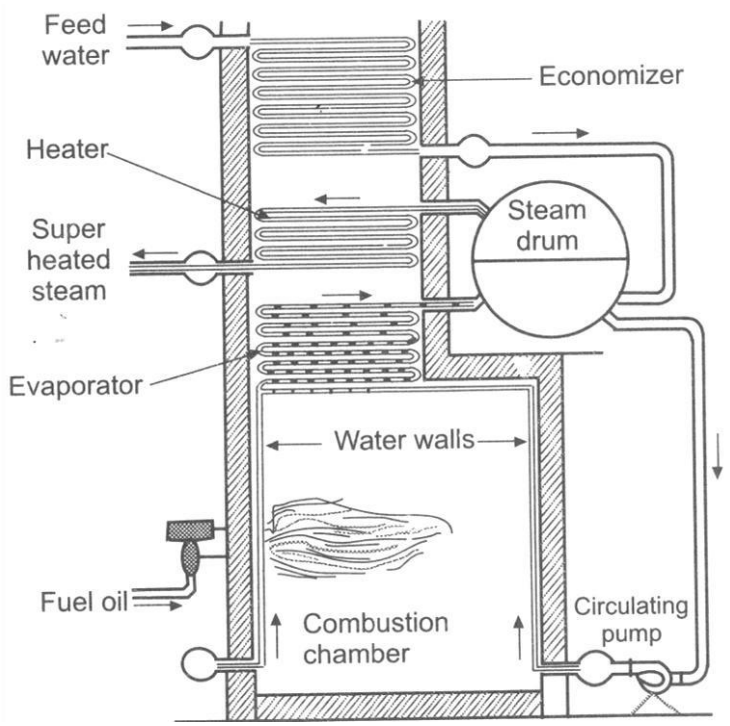
| | **c)** | **Draw neat labelled sketch of 'La-Mont Boiler'** | **04** |
| | | (sketch 02 marks, labelling 02 marks)<br>  <br><br>**La-Mont Boiler** | **04** |
| | **d)** | **Describe phases of steam formation.** | **04** |
| | | **(*Note: Description: 2 marks and Diagram:2 marks.)***<br><br>Different phases of Formation of steam-<br>Consider formation of steam from ice at -10o C<br>i) Solid phase- When the heat is added in ice which is at -10o C, the temperature of ice increases to 0o C as shown in figure by process a-b.in this stage solid phase exists.<br>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.<br>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.<br>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.<br>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 | **02** |

region only vapour is present.

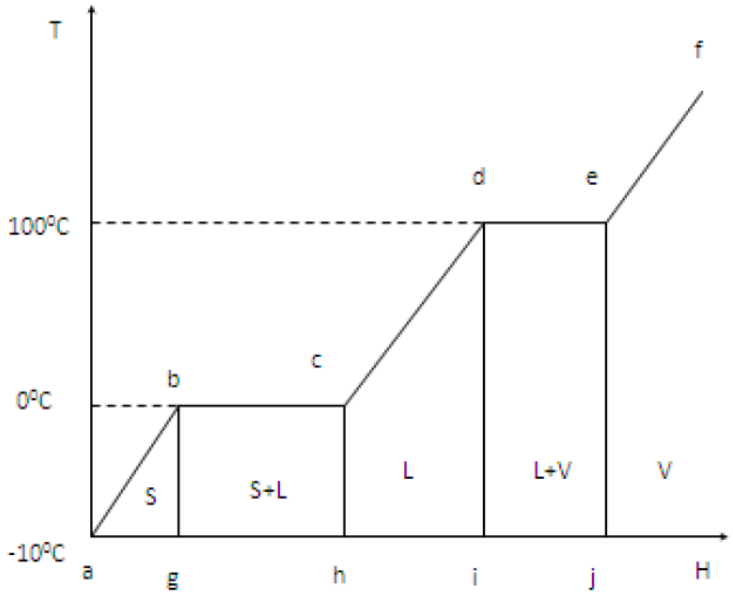



Fig. Formation of steam — **02**

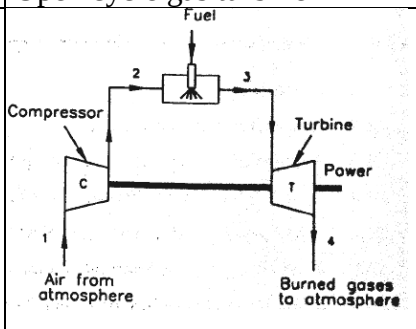
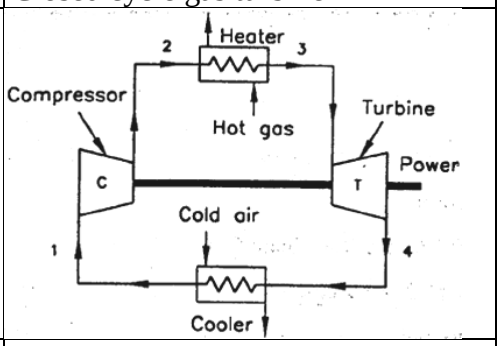
**e) State the factors affecting volumetric efficiency of air compressor.** — **04**

**Factors affecting volumetric efficiency of reciprocating air compressor:**
(Any 4 points)
1) Clearance Volume
2) Restricted passage and leakage at inlet valves
3) Speed of rotation
4) Piston ring leakages
5) If fresh air comes in contact with hot wall, it get expanded, which decreases the charge taken in therefore volumetric efficiency decreases.

— **04**

**f) Differentiate between open cycle and closed cycle gas turbine.** — **04**

(any four points- 4 marks)

| Sr | Open cycle gas turbine | Closed cycle gas turbine |
|---|---|---|
| 1. |   |   |
| 2. | Only air can be used as a | Any type of working fluid with better |

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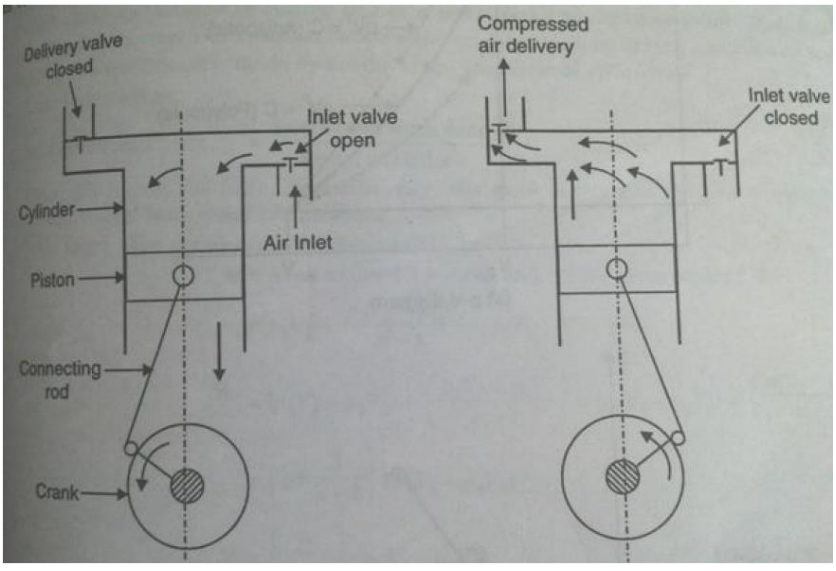
|---|---|---|---|---|
| | | | working fluid. | thermodynamic properties can be used. |
| | | 3. | Maintenance cost is low. | Maintenance cost is high. |
| | | 4. | Working fluid replaced continuously. | Working fluid circulated continuously. |
| | | 5. | Mass of installation per KW is less. | Mass of 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. |
| | | | | **04** |
| 03 | | Attempt any **FOUR**: | | 16 |
| | a) | Explain working of single stage reciprocating air compressor. | | 04 |
| | |  <br>Single stage reciprocating air compressor consists of the following main components.<br>1) Suction Valve, 2) Delivery Valve, 3) Piston Cylinder arrangement etc. | | 02 marks |

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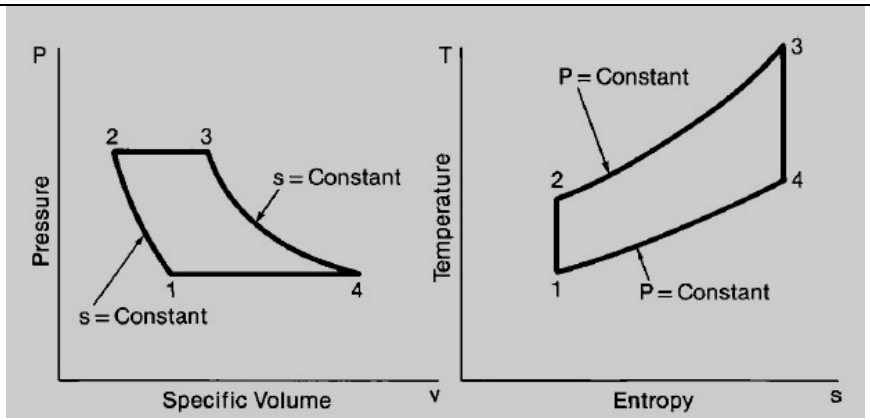
|---|---|---|---|
| | | In single stage reciprocating air compressor without clearance volume there are main three strokes-i) Suction, ii) Compression & iii) Delivery. While with clearance volume there are four strokes i) Expansion ii) suction iii) compression iv) Delivery. When piston moves from T.D.C. to B.D.C., Pressure inside the cylinder falls below an atmospheric pressure. Due to this pressure difference suction valve gets opened and air is sucked into the cylinder. Now the piston moves upwards from B.D.C. to T.D.C. pressure inside the cylinder goes on increasing till it reaches the discharge pressure. At this stage delivery valve gets opened and air is delivered to container. When compression stroke is taking place both suction and delivery valve are closed.<br>This process is repeated continuously. When pressure of air increases automatically volume of air decreases and temperature of air increases. In single stage, single acting, reciprocating air compressor, suction, compression and delivery of air takes place in two strokes of piston (or) one revolution of crankshaft. | 02 marks |
| | b) | Draw Brayton cycle on P-V and T-S diagram. | 04 |
| | |  <br>P-V diagram T-S diagram<br>Fig. Brayton Cycle | 02 marks for each diagram |
| | c) | Sketch with neat labels, the gas turbine power plant. | 04 |

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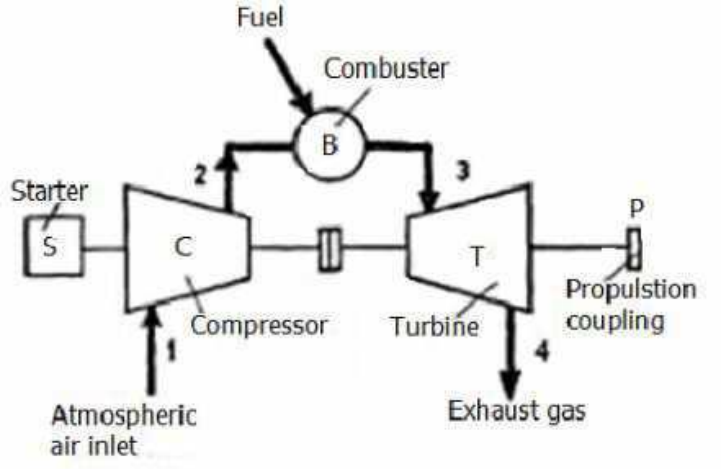
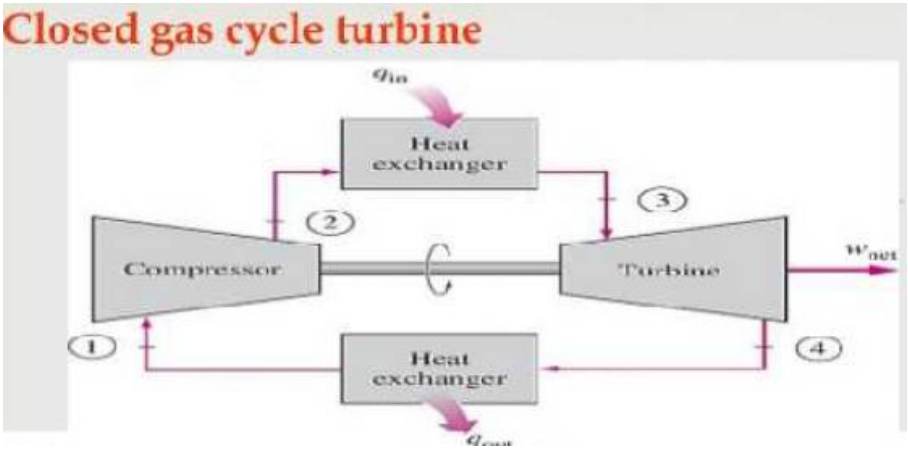
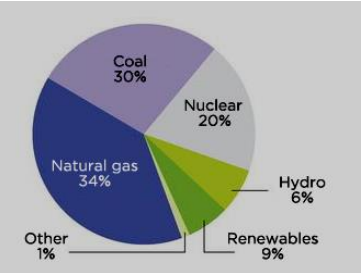
|---|---|---|---|
| | |  <br>OR<br>  | 03 marks<br>Sketch<br>01 marks labels |
| | d) | Explain the importance of non-conventional power generation system in the present situation of power shortage throughout the world. | 04 |
| | Ans: | Recent scenario reveals the imbalance in power generation and power demand in many of the countries. Major amount of power is generated through thermal power plants across the globe. For Thermal power plants we need non-renewable fuel sources some of them are Coal, Nuclear materials etc., As we know the percentage Coal depreciates continuously, we need different ways of power generation using renewable energy sources like solar energy, wind energy, Tidal energy, Geo thermal energy etc. Power outage problems are very often in future due to lack of Non-renewable inputs. So for the un interrupted power utilization we have to adapt Non-Conventional methods of power generation. In this paper several Non-Conventional methods are proposed along with their principle advantages.<br>Energy saving is not our aim it should be our attitude. We have to depend on Renewable energy sources in future otherwise several | 04 marks |

environmental disasters we have to observe. Moreover need of power demand is increasing day by day and efficient power Transmission is fatigue now because of nonlinear loads. Ultimately the Non-conventional resources will help us in many ways if we use them in a perfect and efficient way of operation and utilization. Solar and Biomass power plants are cost effective and very efficient whereas Wind turbine and Tidal Basin constructions are very complex require so much capital cost. Fuel cells are most Environmental friendly power Generating options compared to other Renewable Sources.




e) Compare Ultimate analysis and proximate analysis of solid fuels. — 04

| Ultimate analysis | proximate analysis |
|---|---|
| In ultimate analysis a complete breakdown of coal into its chemical Constituents is carried out by chemical process. | In this analysis separation of coal into its physical components. This analysis made by means of chemical balance and temperature controlled furnace. |
| This analysis gives percentage of carbon, hydrogen, oxygen, sulphur and ash on mass basis their sum is taken as equal to 100%. | In this analysis sample is heated into furnace. The components in analysis are fixed, carbon, volatile matter, moisture and ash. |
| This analysis is important for large scale trials i.e. boiler trial. | This analysis also used to determine heating value of the coal. |
| In this analysis moisture is consider as separate item. | These components are expressed in percentage on mass basis and their sum is taken as 100% sulphur is determined separately |

01 marks each

| | | | |
|---|---|---|---|
| | f) | A sample of coal has following composition of mass carbon = 61%, Hydrogen=10%, Oxygen=14%, Sulper=3.5% and remainder is ash. Calculate higher and lower calorific value of coal per Kg. | 04 |
| | | Answer:-<br>Carbon C = 61 % = 0.61<br>Hydrogen = H2 = 10 % = 0.10<br>Oxygen = O2 = 14 % = 0.14<br>Sulphur = S =3.5 % = 0.035<br>Ash = 11.5 % = 0.115<br>Dulong's formula:<br>H.C.V. of coal = 33800 C + 144500 ( H2 - O2/8 ) + 9300 S KJ / Kg<br>=33800 x 0.61 + 144500 (0.10 - 0.14/8) + 9300 x 0.035<br>= 20618 + 11921.25 + 325.5<br>= 32864.75 KJ / Kg<br><br>H.C.V. of coal = 32864.75 KJ / Kg<br>L.C.V. of coal = H.C.V.- 9H2 x 2442 KJ / Kg<br>= 32864.75 – 9 x 0.10 x 2442<br>L.C.V. of coal = 30666.95 KJ / Kg | 02 marks<br><br>02 marks |

| | | | |
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| 04 | | Attempt any TWO: | 16 |
| | a) | Compare conventional and non-conventional energy sources (min.8 points) | 08 |
| | | | 01 marks each |

| Sr. No. | conventional source of energy | Non-conventional source of energy |
|---|---|---|
| 1 | These are non-renewable energy sources | These are renewable energy sources |
| 2 | Creates pollution | Does not creates pollution |
| 3 | It is not clean energy source | It is clean energy source |
| 4 | Harnessing cost is more | Harnessing cost is less |
| 5 | Efficiency is more | Efficiency is less |
| 6 | Fuel is required | Fuel is not required |
| 7 | Exhaustible energy source | Non-Exhaustible energy source |
| 8 | Affects on ozone layer | Does not affects on ozone layer |
| 9 | Ex.-Petrol, Diesel, Kerosene etc. | Ex.-Solar, Wind, Tidal, Geothermal, Biomass, Etc. |

| | | | |
|---|---|---|---|
| | b) | Describe the combustion chemistry of carbon, hydrogen and methane. | 08 |
| | | i) **Carbon**: Burning of carbon to carbon dioxide ( complete combustion ) | 02 marks |

$C + O_2 \rightleftharpoons CO_2$

i.e. $12 + (16 \times 2) = 12 + 16 \times 2$

i.e. $12 + 32 = 44$

$1 + 2.67 = 3.67$

That means 1 kg of carbon needs 2.67 kg oxygen and produces 3.67 kg of carbon dioxide

2)hydrogen

The union of hydrogen with oxygen produces steam it is represented by the following equitation — 3 marks

$2H_2 + O_2 = 2H_2O$

$2(1 \times 2) + (16 \times 2) = 2(1 \times 2 + 16)$

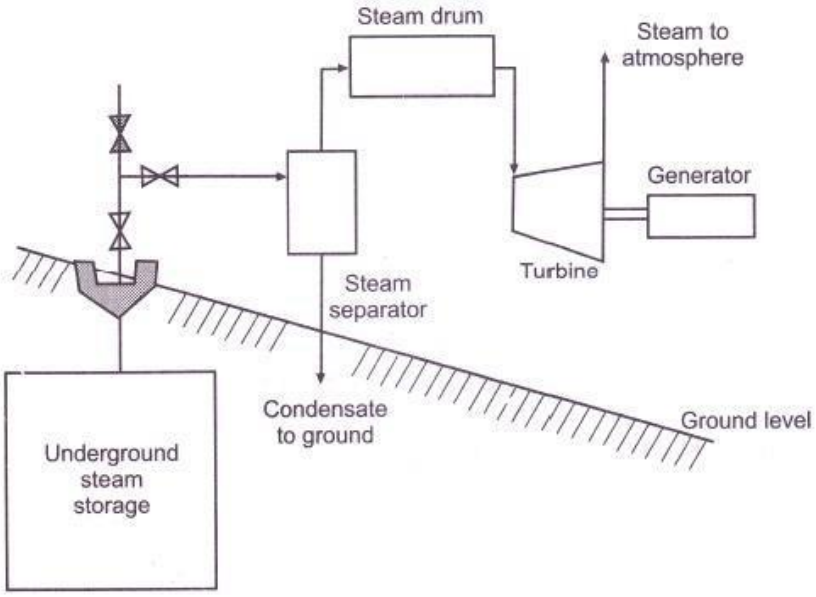
$1 + 8 = 9$

1 kg of hydrogen combines with 8 kg of oxygen to produce 9 kg of steam.

3)methane

Burning of methane with oxygen to carbon dioxide and water/ steam — 03 marks

$CH_4 + 2O_2 \rightleftharpoons CO_2 + 2H_2O$

| | | | |
|---|---|---|---|
| | | i.e. $(12+1\times4)+2(16\times2)=(12+16\times2)+2(1\times2+16)$<br>$16+64=44+36$<br>$1+4=\frac{11}{4}+\frac{9}{4}$<br>That means 1 kg of methane needs 4 kg of oxygen to produce 11/4 kg of carbon dioxide and 9/4 kg of water /steam | |
| | c) i ) | Explain Geothermal power plant. | 08 |
| | |  <br>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 marks sketch<br>02 marks explain |
| | ii) | Explain H.C.V. and L.C.V. of fuels. | 04 |
| | | H.C.V.:- It is a total heat is liberated by complete burning of 1 kg or 1m3 of fuel including heat of steam formed by combustion of Hydrogen in the fuel.<br>The amount of heat obtained by complete combustion of fuel, when the products of its combustion are cooled down to temperature of surrounding supplied air (i.e. 15oC) is called as higher calorific value. | 02 marks |

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| | | If C, H, O and S are the percentage of Carbon, Hydrogen, Oxygen and Sulphur by weight respectively present in a fuel then the higher calorific value of fuel can be calculated from formula known as Dulong's formula.<br><br>L.C.V:- It is a total heat is liberated by complete burning of 1 kg or 1m3 of fuel deducting heat of steam formed by combustion of Hydrogen in the fuel.<br>When heat absorbed (or) carried away by the products of combustion is not recovered and steam is formed during combustion is not condensed then amount of heat obtained per Kg of fuel is known as net (or) lower calorific value.<br>If H.C.V. is known then L.C.V. is obtained by<br>L.C.V. = H.C.V. – Heat of steam formed during combustion let.<br>mS= Mass of steam formed in KJ/Kg. of fuel = 9 H2 | 02 marks |
| **05** | | **Attempt any <u>TWO</u> :** | **16** |
| | **a)** | **Derive the relation between P,V & T for adiabatic process.** | **08** |
| | | Answer:<br>**Relation between P, V and T during Adiabatic Process: Pressure ( P ) , Volume ( V ) & Temperature ( T ) relation for adiabatic process:**<br>For adiabatic Process,<br>$PV^{\gamma} = C$<br>$P_1 v_1^{\gamma} = P_2 v_2^{\gamma}$<br>$\frac{P_2}{P_1} = (\frac{V_1}{V_2})^{\gamma}$ ..... (1)<br>From general gas equation<br>$\frac{PV}{T} = C$<br>$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$<br>$\frac{T_2}{T_1} = \frac{P_2 V_2}{P_1 V_1}$ .....(2)<br>From (1)<br>$\frac{V_2}{V_1} = (\frac{P_1}{P_2})^{1/\gamma}$ ..... (3)<br>Put equation (3) into equation (2)<br>$\frac{T_2}{T_1} = \frac{P_2}{P_1} (\frac{P_1}{P_2})^{1/\gamma}$<br>$\frac{T_2}{T_1} = (\frac{P_2}{P_1})^{\frac{\gamma-1}{\gamma}}$<br>$\frac{P_2}{P_1} = (\frac{T_2}{T_1})^{\frac{\gamma}{\gamma-1}}$ .....(4) | **01**<br>**01**<br>**01**<br>**01**<br>**02** |

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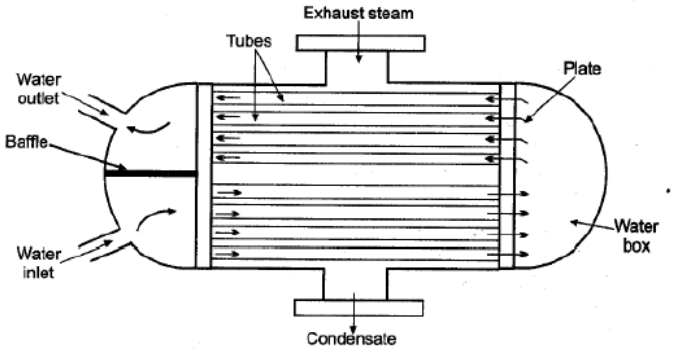
| | | From equation (1) & (4)<br>$\frac{P_2}{P_1} = (\frac{V_1}{V_2})^{\gamma} = (\frac{T_2}{T_1})^{\frac{\gamma}{\gamma-1}}$<br>$\frac{P_2}{P_1} = (\frac{V_1}{V_2})^{\gamma} = (\frac{T_2}{T_1})^{\frac{\gamma}{\gamma-1}}$ | **02** |
| | **b)** | Draw a neat sketch of two pass down flow type surface condenser. Describe its construction and working | **08** |
| | **Ans:** | **Answer: Two pass down flow surface condenser:** (*Construction and Working: 4 marks, Diagram: 4 marks)*<br>**Construction:** It consists of horizontal cast iron cylindrical vessel pack with tubes, through which the cooling water flows. The ends of the condenser are cut off by vertical perforated type plates in to 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.<br>**Working:** The water tubes pass horizontally through the main condensing space for the steam. The steam enters at the top & is forced to flow downwards over the tubes due to the suction of the extraction pump at the bottom. The cooling water flows in one direction through lower half of the tubes & return in opposite direction through the upper half as shown in figure. The condensate does not mix with cooling water which is used for cooling steam & convert into water; therefore whole condensate can be the reused in the boiler. It is used to increase the turbine output by maintaining backpressure on exhaust side of steam engine or turbine & the secondary function of condenser is to supply pure and hot feed water to boiler.<br>  <br><br>Fig. Two pass down flow surface condenser<br>*(Credit should be given to equivalent sketch)* | **02**<br>**02**<br>**04** |

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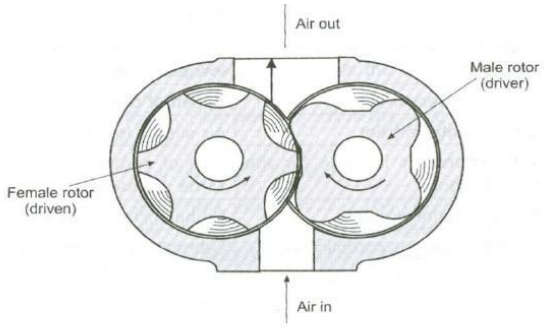
| | **c)** | Describe with neat sketch, construction and working of screw compressor. State its advantages. | **08** |
| | **Ans:** | **Screw compressor:**<br>  <br><br>Fig. Screw Compressor<br><br>**Construction:** It consists of two mutually engaged helical grooved rotors which are suitably housed 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.<br><br>**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.<br>**Advantages of screw compressor: (Any Four)**<br><br>1. Maintenance is simple in screw based air compressors<br>2. Minimum oil-carryover<br>3. Ability to function in rough and harsh environments<br>4. Lesser consumption of oil<br>5. Minimum heat generation<br>6. Shockless compression technology<br>7. Very less noise levels<br>8. Lighter and portable<br>**9.** Nil reduction in capacity over a period of time | **02**<br><br>**02**<br><br>**02**<br><br>**02** |

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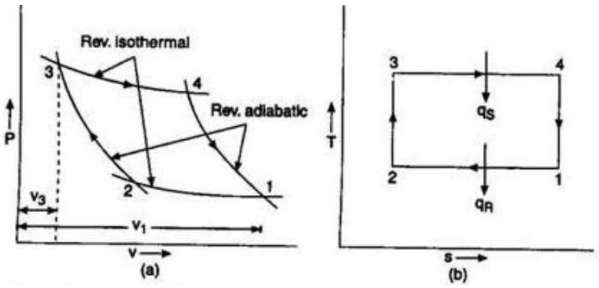
| 6 | | **Attempt any FOUR :** | **16** |
| | **a)** | State the equation for air standard efficiency for carnot cycle and show it on P-V and T-S chart. State one reason why this cycle is not practical. | **04** |
| | **Ans:** | Carnot Cycle:<br>  <br><br>(a)PV Diagram **(b) T-S Diagram**<br>Fig. Carnot cycle<br>**Air standard efficiency of Carnot Cycle:-**<br>**$\eta$ = (T1-T2) / T1**<br>Where, T1= temperature of source<br>T2= temperature of sink<br><br>The Carnot cycle *cannot be performed in practice* because of the following **reasons** : **(for Any one Reason 1 Mark)**<br>1. It is impossible to perform a frictionless process.<br>2. It is impossible to transfer the heat without temperature potential.<br>3. Isothermal process can be achieved only if the piston moves very slowly to allow heat transfer so that the temperature remains constant. Adiabatic process can be achieved only if the piston moves as fast as possible so that the heat transfer is negligible due to very short time available. The isothermal and adiabatic processes take place during the same stroke therefore the piston has to move very slowly for part of the stroke and it has to move very fast during remaining stroke. This variation of motion of the piston during the same stroke is not possible. | **02**<br>**01**<br>**01** |

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| | **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 loss 21 kJ of heat per kg as it flows through the pipe line pressure remaining constant. Calculate dryness fraction of steam at engine end of the pipeline.<br>(From Steam Table P=15 bar, $h_g$ = 844.6 kJ/kg and $h_{fg}$ = 1945.3 kJ/kg) | **04** |
| | | Given Data:<br>$P_1 = 15$ bar $= P_2$<br>$x_1 = 0.98$<br>Heat Loss = 21 KJ /kg<br>Properties of steam At 15 bar<br>$h_f$ = 844.6 KJ /kg<br>$h_{fg}$ = 1945.3 KJ /kg<br>Enthalpy of stream at boiler end is<br>$h_1 = h_{f1} + x_1 . h_{fg1}$<br>$= 844.6 + (0.98 \times 1945.3)$<br>$= 2750.994$ KJ /kg<br>As steam losses 21 KJ /kg of heat, while passing upto engine end , therefore Enthalpy of steam at engine end is,<br>$h_2 = h_1 -$ Heat loss<br>$= 2750.994 - 21$<br>$= 2729.994$ KJ /kg<br>We Know<br>$h_2 = h_{f2} + x_2 . h_{fg2}$<br>$\therefore 2729.994 = 844.6 + (x_2 \times 1945.3)$<br>$\therefore$ **$x_2 = 0.9692$** .....**ANS.** | **01**<br>**01**<br>**02** |
| | **c)** | State necessity of multi-staging and intercooling of air compressor | **04** |
| | | **Answer: Necessity of multi-staging and inter-cooling of air compressor:** 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<br>1. The size of cylinder will be too large.<br>2. Work required to drive the compressor is more<br>3. Due to high pressure loss of air due to leakage is more.<br>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.<br>5. Volumetric efficiency of compressor is less | **04** |

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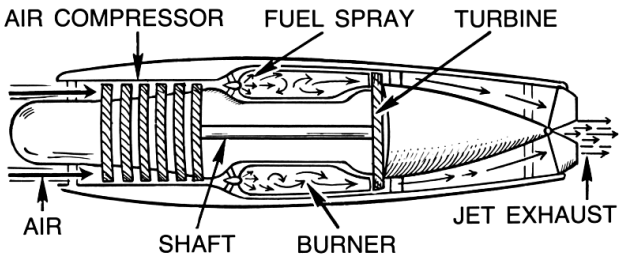
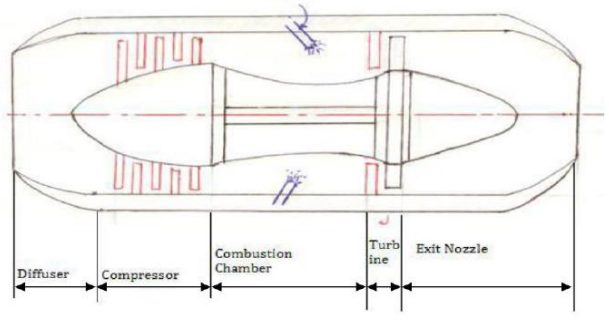
| | | In order to overcome the above mentioned difficulties two or more cylinders are provided in series with inter-cooling arrangement between them. Such an arrangement is known as multistage compression with inter-cooling.<br><br>OR<br>**Necessity of multistaging –**<br>For producing high pressure i.e. more than 8 bar, single stage air compressor suffers fallowing drawbacks-<br>i) Size of cylinder is too large<br>ii) Rise in temperature of air is very high.<br>To avoid this difficulty multi-staging is necessary.<br>**Necessity of intercooling –**<br>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. | **OR**<br><br>**02**<br><br>**02** |
| | **d)** | **Explain construction and working of turbojet engine.** | **04** |
| | | **Turbo-jet Engine**<br><br>  <br><br>Fig. Turbo-jet Engine<br><br>**OR**<br><br>  <br><br>**Fig. Turbo-jet Engine** | **02** |

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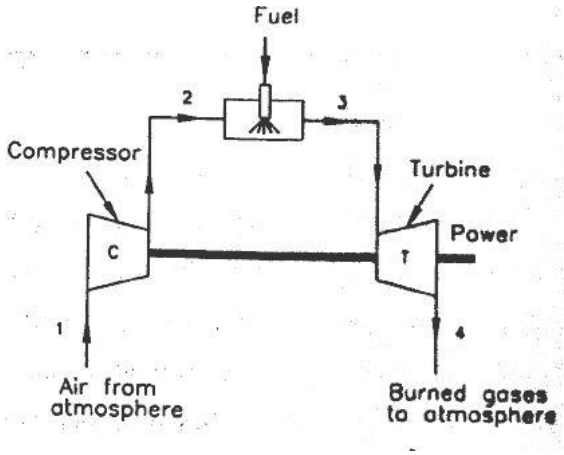
| | | Turbo-jet engine consists of diffuser, compressor, combustion chamber turbine and nozzle. At entrance air diffuser causes rise in pressure in entering air by slowing it down. A rotary compressor, which raises the pressure of air further to required value and delivers to the combustion chamber. 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.<br>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)** | **Explain the construction and working of open cycle gas turbine.** | **04** |
| | | **Open Cycle Gas Turbine.**<br>  <br><br>**Fig. Open Cycle Gas Turbine**<br><br>**Working:**<br>Fig. shows open cycle gas turbine which consists of compressor, combustion chamber, turbine, generator. The compressor and turbine are mounted on same shaft. Combustion chamber is placed in between compressor and turbine for combustion of fuel. Generator is coupled with turbine shaft for generation of power. Fresh air enters the compressor at ambient temperature at point 1 and it is compressed to point 2 where its pressure and temperature are increased. The high pressure air enters the combustion chamber where the fuel is burned at constant pressure. Heat is added by directing burning the fuel into combustion chamber at constant pressure during process 2 to 3. The high temperature (and pressure) gas enters the turbine where it expands during process 3 to 4 to ambient pressure and produces work. Finally exhausted to atmosphere. | **02**<br><br>**02** |

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| | **f)** | **Compare centrifugal and axial flow compressor.** | **04** |
| | **Ans:** | **Comparison between Centrifugal and Axial flow compressor. (Any Four)** | **04** |

| 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. |