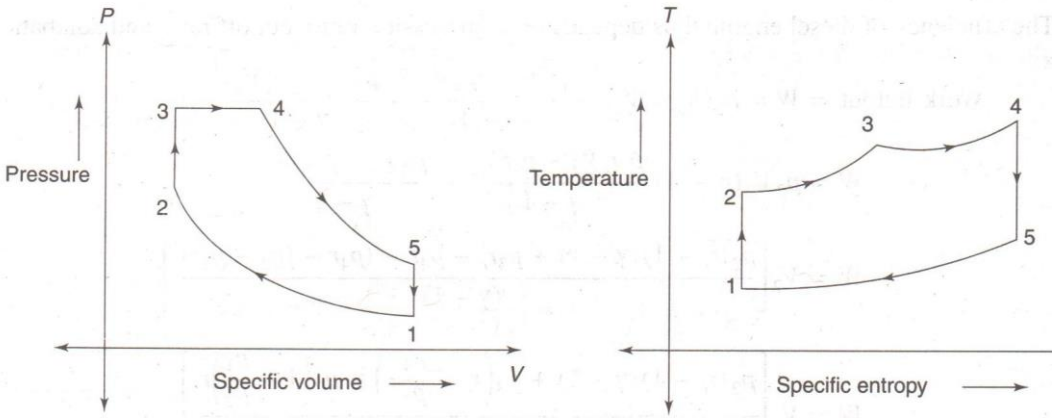
SUMMER – 19 EXAMINATION

Subject Name: Power Engineering **Model Answer** **Subject Code:** 17529

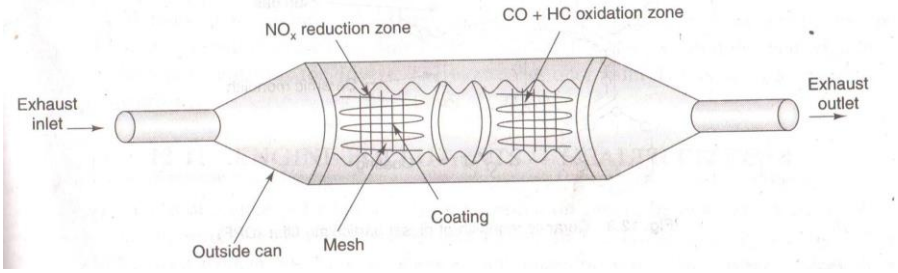
Important Instructions to examiners:

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.1 (A)		**Attempt any THREE**	
	a	**Represent P-V and T-S diagram for dual cycle and name the processes involved in it.** **Duel cycle:**  Following process are involved in duel cycle 1. 1-2 Isentropic compression 2. 2-3 Constant volume heat addition 3. 3-4 Constant pressure heat addition 4. 4-5 Isentropic expansion 5. 5-1 Constant volume heat rejection	**02 for sketch** **02 for processes**
	b	**Classification of Air compressors**: 1. According to principle: a) Reciprocating air compressors b) Rotary air compressors	**01 for each**

		2. According to the capacity a. Low capacity air compressors b. Medium capacity air compressors c. High capacity air compressors 3. According to pressure limits a. Low pressure air compressors b. Medium pressure air compressors c. High pressure air compressors 4. According to method of connection a. Direct drive air compressors b. Belt drive air compressors	
	c	**Following are the applications of compressed air** 1) To drive air motors in coal mines. 2) To inject fuel in air injection diesel engines. 3) To operate pneumatic drills, hammers, hoists, sand blasters. 4) For cleaning purposes. 5) To cool large buildings. 6) In the processing of food and farm maintenance. 7) For spray painting in paint industry. 8) In automobile & railway braking systems. 9) To operate air tools like air guns. 10) To hold & index cutting tools on machines like milling.	**(Any Eight) 1/2 mark each**
	d	**(i) According to method of cooling** a. Air cooled engine, **b.** Water cooled engine**.** **(ii) According to the number of strokes per cycle** a. Two stoke engine,	**01 for each**

		b. four stroke engine **(iii) According to method of igniting fuel** a. SI engine b. CI engine c. Hot spot ignition engine **(iv)According to use** a. Stationary engine b. Automotive engine c. Marine engine d. Aircraft engine e. Locomotive engine.	
	(B)	**Attempt any ONE**	
	a.	Q1 (B) (a) I.P./cylinder $= P_m \cdot L \cdot A \cdot \frac{N}{n}$ $= 5 \times 10^5 \times 0.15 \times \frac{\pi}{4}(0.1)^2 \times \frac{1250}{2 \times 60}$ $= 6.138$ KW — (2) Total I.P. $= 6.138 \times$ no. of cylinder $= 6.138 \times 4 = 24.55$ KW — (1) $\eta_{mech} = \frac{B.P.}{I.P.}$ — (1) $0.8 = \frac{B.P.}{24.55}$ Power available at crankshaft = B.P. = 19.64 KW — (2)	**06**
	b	A catalytic converter is a device which reduces pollutants like HC,CO and NOx . If all three pollutants are reduced simultaneously, it is called a 3-way catalyst. Usually a catalyst contains a mesh coated with noble metals like platinum, rhodium and palladium. . These metals are catalysts which accelerate the oxidation of CO to CO2 and HC to H2O and CO2 and reduce NOx to N2 . The catalyst themselves do not participate in the reaction The front part of the catalyst is for NOx reduction and rear part is for CO and HC oxidation.	**06**



Three way catalytic converter

Q.2 **Attempt any TWO**

a

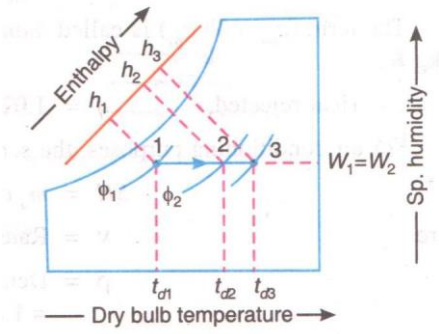
Reciprocating compressor	Rotary compressor
1. Compression of air takes place with help of piston and cylinder arrangement with reciprocating motion of piston.	1. Compression of air takes place due to rotary motion of blades.
2. Delivery of air intermittent.	2. Delivery of air is continuous.
3. Delivery pressure is high i.e. pressure ratio is high.	3. Delivery pressure is low, i.e. pressure ratio is low.
4. Flow rate of air is low.	4. Flow rate of air is high.
5. Speed of compressor is low because of unbalanced forces.	5. Speed of compressor is high because of perfect balancing.
6. Reciprocating air compressor has more number of moving parts.	6. Rotary air compressor has less number of moving part.
7. It needs proper lubrication and more maintenance.	7. It required less lubrication and maintenance.
8. Due to low speed of ration it can't be directly coupled to prime mover but it requires reduction of speed.	8. Rotary air compressor can be directly coupled to prime mover.
9. It is used when small quantity of air at high pressure is required.	9. It is used where large quantity of air at lower pressure is required.

01 for each any eight

b Explain the following Psychometric processes and represent it on Psychometric chart

(i) Sensible heating

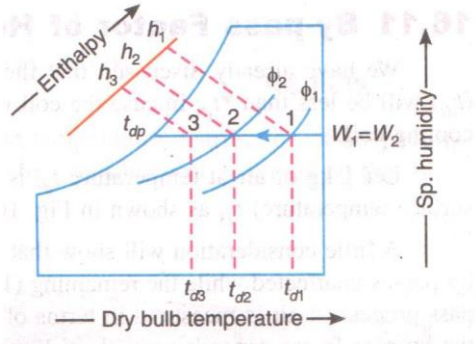
Sensible heating : The heating of air without any change in its specific humidity, is known as sensible heating



Sensible heating

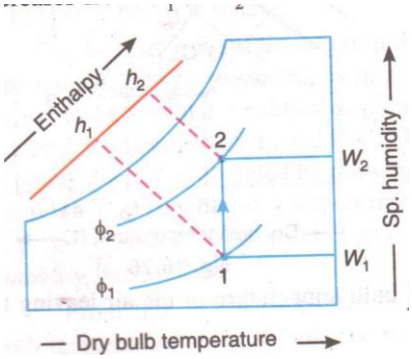
02 for each

(ii) **Sensible cooling**: The cooling of air without any change in its specific humidity, is known as sensible cooling

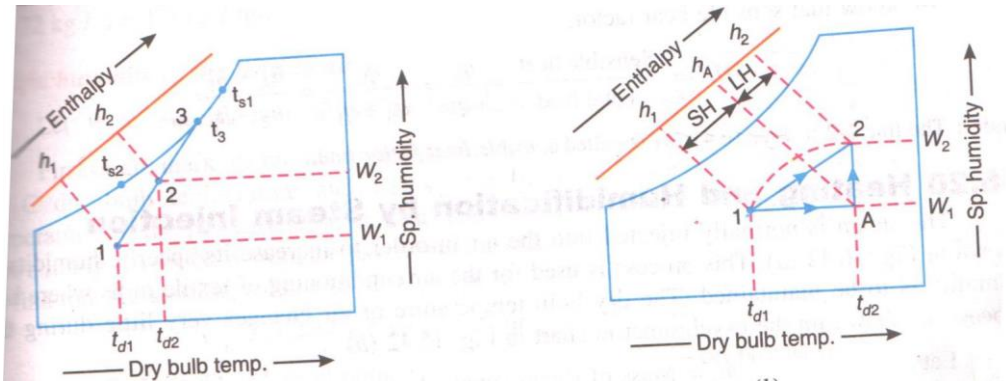


Sensible cooling

(iii) **Humidification**: The addition of moisture to the air without change in its dry bulb temperate is known as humidification .



(iv)**Heating and humidification**: It is the process generally used in winter air conditioning to warm and humidify the air . It is the reverse process of cooling and dehumidification.



	c		08

Q2 (c) B.P. with all cylinder working = 16.25 kW

$I.P_1 = (B.P.)_{\text{all cylinder working}} - (B.P.)_{2,3,4}$

$= 16.25 - 11.55 = 4.7$ kW

$I.P._2 = 16.25 - 11.65 = 4.6$ kW

$I.P._3 = 16.25 - 11.70 = 4.55$ kW

$I.P._4 = 16.25 - 11.50 = 4.75$ kW

} 2 marks

Total $I.P. = I.P_1 + I.P_2 + I.P_3 + I.P_4$

$= 4.7 + 4.6 + 4.55 + 4.75$

$= \underline{18.6 \text{ kW}}$ — 2 marks

$\eta_{mech} = \frac{B.P.}{I.P.} = \frac{16.25}{18.6} = \underline{87.36\%}$ — 1 mark

$V_s = \frac{\pi}{4} d^2 l = \frac{\pi}{4} \times (6)^2 \times 9$

$= \underline{254.57 \text{ cm}^3}$ — 1 mark

Compression Ratio $= 1 + \frac{V_s}{V_c}$

$= 1 + \frac{254.57}{60}$

$= 1 + 4.24$

$= \underline{5.24}$ — (1)

$\eta_{Air\ std.} = 1 - \frac{1}{r_c^{\gamma - 1}}$

$= 1 - \frac{1}{5.24^{1.4-1}}$

$= \underline{48.44\%}$ — (1)

$\eta_{relative} = \frac{\eta_{i+h}}{\eta_{air\ std.}} = \frac{0.3163}{0.4844}$

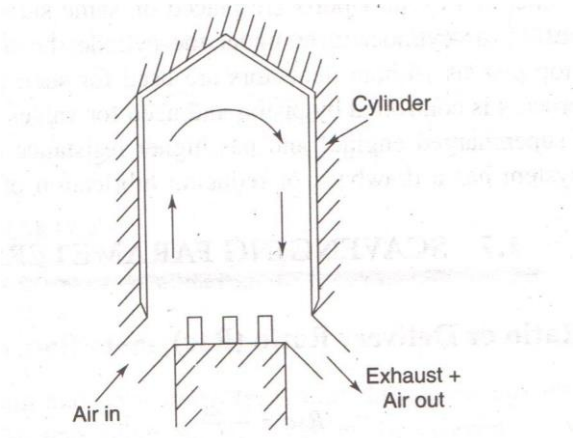
$= \underline{65.29\%}$ — (1)

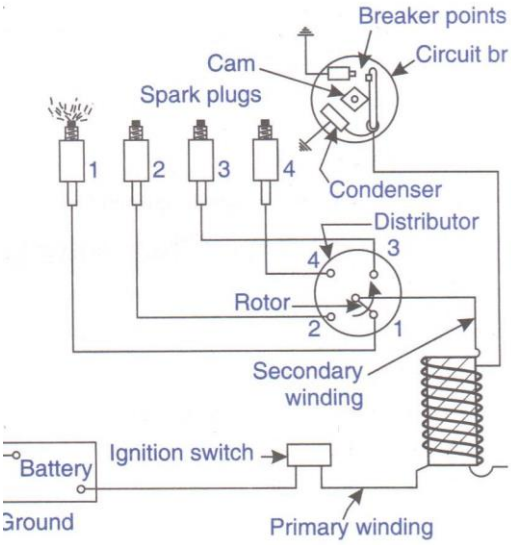
$\eta_{indicated\ thermal} = \frac{I.P.}{mf \times C.V.}$

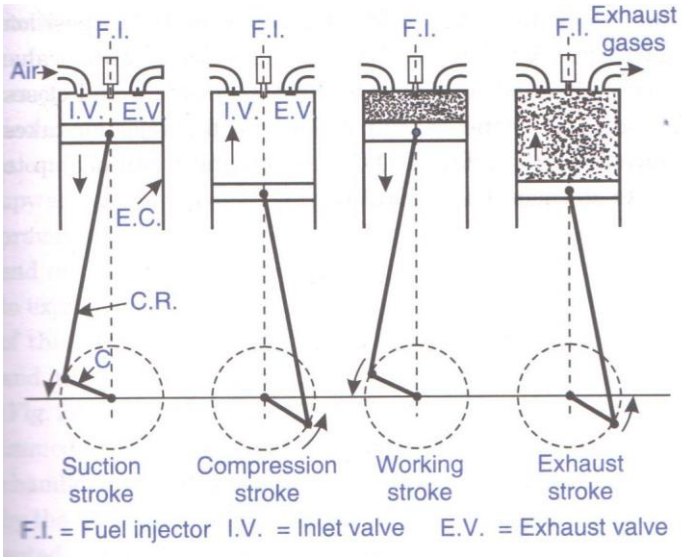
$= \frac{18.6}{0.0014 \times 42000}$

$= \underline{31.63\%}$ — (1)

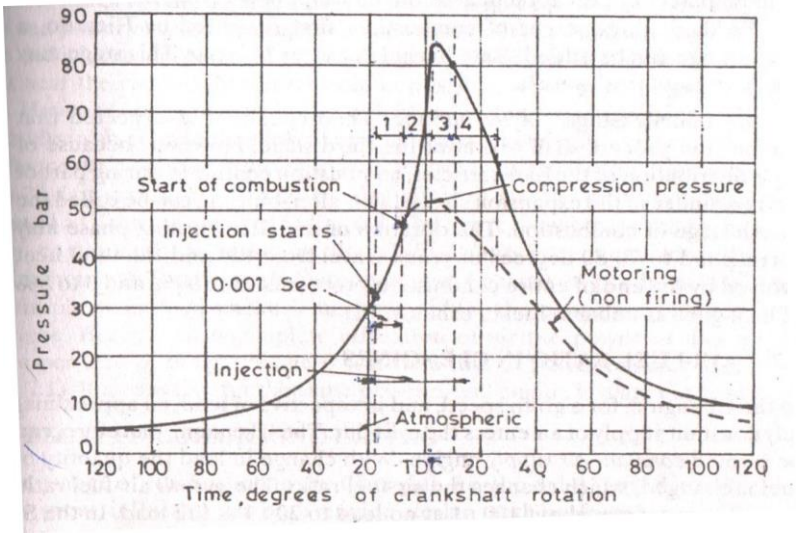
Q.3		**Attempt any FOUR**	
	a	The major air pollutants emitted by petrol & diesel engines are CO_2, CO, HC, NO_x, SO_2, smoke & lead vapour. **Effect of CO**: • Carbon monoxide combines with haemoglobin forming carboy haemoglobin, which reduces oxygen carrying capacity of blood. • This leads to laziness, exhaustion of body & headache. • Prolong exposure can even leads to death. • It also affects cardiovascular system, thereby causing heart problem **Effect of CO_2:** Causes respiratory disorder & suffocation. **Effect of NO_x:** It causes respiration irritation, headache, bronchitis, pulmonary emphysema, impairment of lungs, and loss of appetite & corrosion of teeth to human body. **Effect of HC:** • It has effect like reduced visibility, eye irritation, peculiar odour & damage to vegetation & acceleration the cracking of rubber products. • It induce cancer, affect DNA & cell growth are know a carcinogens. **Effect of SO_2:** It is toxic & corrosive gas, human respiratory track of animals, plants & crops.	**02** **02**
	b	Following are the applications of gas turbine 1. It is used for electric power generation. 2. It is used for locomotive propulsion. 3. It is used for ship propulsion. 4. Gas turbine is used in aircrafts. 5. It is used for supercharging for heavy duty Diesel engines. 6. Used in turbo jet and turbo-propeller engine. It is used for various industrial purposes such as in steel industry, oil and other chemical industry.	**01 for each any four**

	c	**State the function of (i) drier and (ii) oil separator in vapor compression cycle** i. **Drier:** The purpose of a refrigerant drier is to ensure the refrigerant system stays clean and dry. It removes contaminants including moisture, dirt, acid and solder flux, beads and filings. Whenever the refrigerant system is opened for repair or to replace a component, always replace the filter drier. **ii. Oil separator**: A certain amount of oil leaves a compressor with the discharged refrigerant vapour. Large quantities may be prevented from circulating in the system by using an oil separator. Oil returns to the compressor after it has been collected in the separator. The oil separates from the discharged vapour because the vapour flow slows as it enters the separator. When a certain level of oil is reached, the float opens a valve to return the oil to the compressor crankcase.	**02** **02**
	d	**Scavenging :** In two stroke engines, at the end of expansion stroke, combustion chamber is full of products of combustion. This is due to elimination of exhaust stroke like in four stroke engine. Scavenging is the process of clearing the cylinder after the expansion stroke. This is done short duration of time available between end of expansion and start of charging process.  **Cross flow scavenging process**	**02** **02**

	e	 **Battery ignition system**	**04**
Q.4	**(A)**	**Attempt any THREE**	
	a	In S.I. engine, the spark is timed to occur at a definite point just before the end of the compression stroke. If the ignition starts, due to any other reason, when the piston is still doing its compression stroke, it is known as pre – ignition. **Following factors are responsible for Pre – ignition** 1) High compression ratio 2) Overheated spark plug 3) Incandescent carbon deposit in cylinder wall 4) Overheated exhaust valve It may occur due to faulty timing of spark production	**02** **02**
	b	(i) **Cut off ratio :** The cutoff ratio is the ratio of the volume after combustion to the volume before combustion. (ii) **Brake specific fuel consumption**: It is the mass of fuel consumed per kw developed per hour, and is a criterion of economical B.S.F.C = $\frac{fuel\ consumption\ in\ Kg/hr}{Brake\ power\ in\ KW}$ (iii) **Mean effective pressure:** Defined as the average pressure acting on the piston which will produce the same output as is done by the varying pressure during the cycle. (iv) **Thermal efficiency**: The thermal efficiency of a heat engine is the percentage of heat energy that is transformed into work. It is the ratio of work done to the energy supplied	**01 for each**

	c	**Explain the working of four stroke CI engine with neat sketch** **Four stroke CI engine**  Four stroke CI engine 1. **Suction stroke**: With the movement of the piston from TDC to BDC during this stroke, the inlet valve opens and the air at atmospheric pressure is drawn inside the engine cylinder, the exhaust valve however remaining closed. 2. **Compression stroke**: The air drawn at atmospheric pressure during the suction stroke is compressed to high pressure and temperature to the value of 35 bar and 600 ^{0}C , as the piston moves from BDC to TDC. Both the inlet and exhaust valves do not open during any part of this stroke 3**. Expansion or power stroke**: As the piston starts moving from TDC, a metered quantity of fuel is injected in the hot compressed air in fine sprays by the fuel injector and it starts burning at constant pressure. The fuel is injected at the end of compression stroke but in the actual practice the ignition of the fuel starts before the end of compression stroke. the hot gases of the cylinder expand adiabatically, thus doing the work on the piston 4**. Exhaust stroke**: The piston moves from BDC to TDC and exhaust gases escape to the atmosphere through the exhaust valve. When piston reaches the TDC, the exhaust valve closes and the cycle is completed.	**02** **02**
	d	Explain motoring test to determine frictional power of engine In this test, the engine is steadily operated at the rated speed for sufficient time to achieve steady state operation. A motoring or absorption dynamometer absorbs the engine power during the test. Now the engine is cut off by switching off the ignition is case of SI engines or fuel in case of CI engines. The dynamometer now becomes a motor and cranks up the engine to the rated speed	**04**

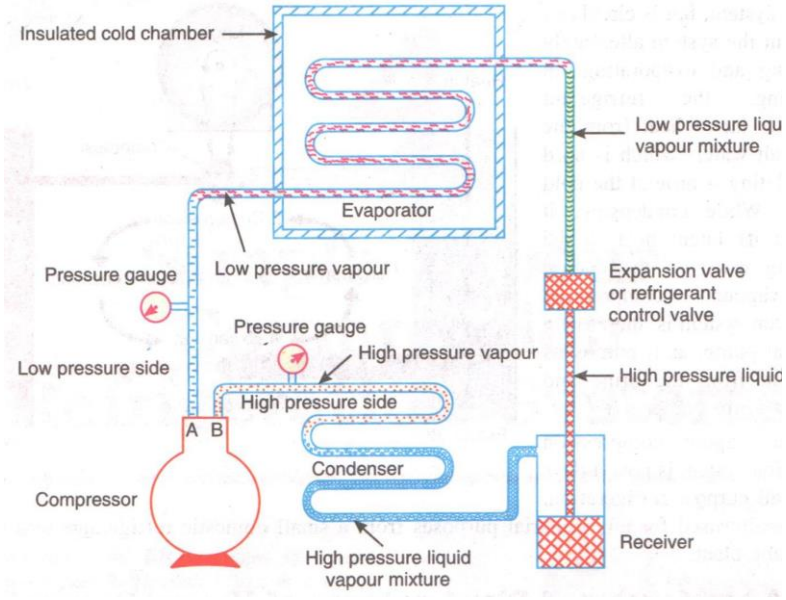
		at which it was operating before. The power is measured and is an indication of frictional power of the engine. Motoring test is not very accurate method, as it ignores losses arising due to clearance between piston and cylinder wall.	
	(B)	**Attempt any ONE**	
	a	**Additives** **(1) Detergents** – To keep engine parts, such as piston and piston rings, clean & free from deposits. **(2) Dispersants** – To suspend & disperse material that could form varnishes, sludge etc that clog the engine. **(3) Anti – wear** – To give added strength & prevent wear of heavily loaded surfaces such as crank shaft rods & main bearings. **(4) Corrosion inhibitors** – To fight the rust wear caused by acids moisture. Protect vital steel & iron parts from rust & corrosion. **(5) Foam inhibitors** – control bubble growth, break them up quickly to prevent frothing & allow the oil pump to circulate oil evenly. **(6)Viscosity index improver** – added to adjust the viscosity of oil. **(7) Pour point depressant** - improves an oil ability to flow at very low temperature	**01 for each any six**
	b	Combustion in CI Engines :The combustion in CI engines is taking place in following stages as shown in figure 1. Ignition delay period: During this period, some fuel has been admitted but not yet ignited. The delay period is a sort of preparatory phase. It is counted from the start of injection to the point where P-θ curve separates from air compression curve. 2. Rapid or uncontrolled combustion: In this stage , the pressure rises rapid because during the delay period the fuel droplets have time to spray and have fresh air around them. This period is counted from end of delay period to the max pressure on indicator diagram. 3. Controlled combustion: uncontrolled combustion is followed by controlled combustion stage. The period of this stage assumed to be at the end of max cycle temperature. 4. After burning: It is expected to end combustion process after third stage. Because of poor distribution of fuel particles combustion still continues during remaining part of expansion stroke. This is after burning.	**03**



03

Q.5 **Attempt any TWO**

a Vapour compression refrigeration cycle: **02**



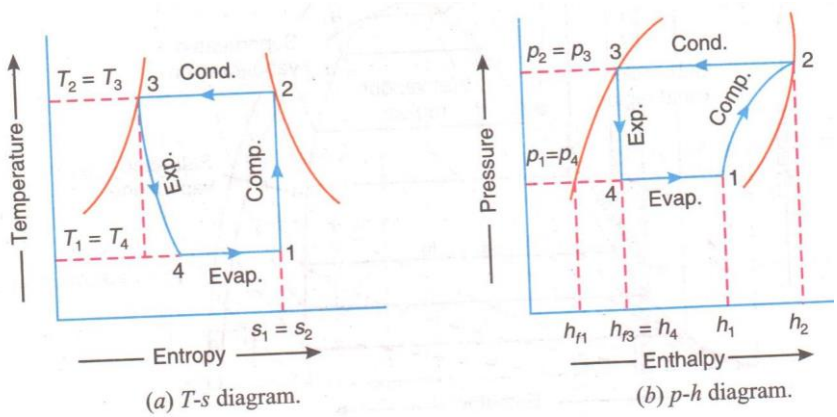
It consists of the following parts . **04**

1. **Compressor:** The low pressure and temperature vapour refrigerant from evaporator is drawn into the compressor through the inlet or suction valve, where it is compressed to a high pressure and temperature. The high pressure and temperature vapour refrigerant is discharged into the condenser through the delivery or discharge valve
2. **Condenser:** It consists of coils of pipe in which the high pressure and temperature vapour refrigerant is cooled and condensed. The refrigerant , while passing through the condenser gives up its latent heat to the surround condensing medium which is normally air or water

3. **Expansion valve**: Its function is to allow the liquid refrigerant under high pressure and temperature to pass at a controlled rate after reducing its pressure and temperature
4. **Evaporator:** It consists of coils of pipe in which the liquid-vapourn refrigerant at low pressure and temperature is evaporated and changed into vapour refrigerant at a low pressure and temperature. In evaporating, the liquid vapour refrigerant absorbs its latent heat of vaporization from the medium which is to be cooled.

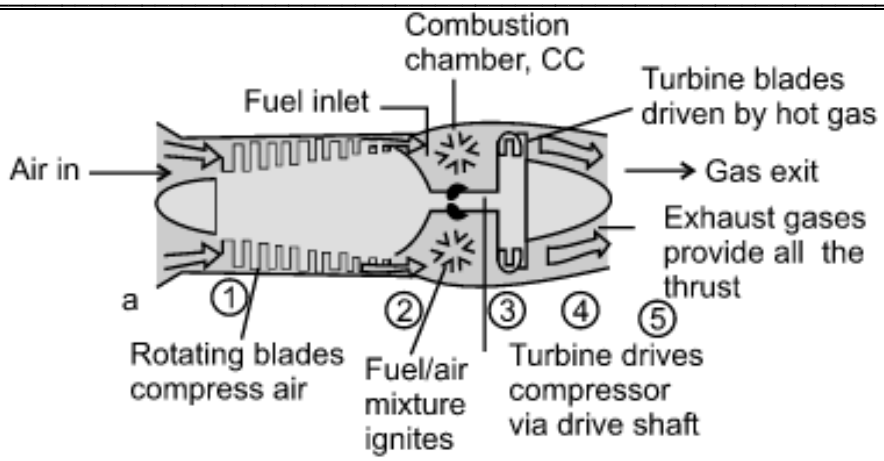
02

P-V and T-S diagram of vapour compression refrigeration cycle



(a) *T-s* diagram. (b) *p-h* diagram.

	b	Q5 (b) Power required to drive Compressor Indicated Power $= \frac{2n}{n-1} mRT_1 \left[\left(\frac{P_3}{P_1}\right)^{\frac{n-1}{2n}} - 1\right]$ $= \frac{2\times1.3}{1.3-1} \times \frac{5}{60} \times 287 \times (288) \left[\left(\frac{15}{1}\right)^{\frac{1.3-1}{1.3\times2}} - 1\right]$ $= 59696 (1.366-1)$ $= 21848.7\ W$ $= 21.85\ kW$ — (3) Isothermal Power $= mRT_1 \log_e \left(\frac{P_2}{P_1}\right)$ $= \frac{5}{60} \times 287 \times 288 \times \log_e \left(\frac{15}{1}\right)$ $= 18653.05\ W$ $= 18.65\ kW$ — (3) Isothermal efficiency $= \frac{\text{Isothermal Power}}{\text{Indicated Power}}$ $= \frac{18.65}{21.85}$ $= 85.35\%$ — (2)	**08**
	c	Working principle of Turbojet: shows the schematic of turbojet engine. It has a diffuser section at inlet for realizing some compression of air passing through this section. Due to this air reaching compressor section has pressure more than ambient pressure. This action of partly compressing air by passing it through diffuser section is called “ramming action” or “ram effect”. Subsequently compressor section compresses air which is fed to combustion chamber and fuel is added to it for causing combustion. Combustion products available at high pressure and temperature are then passed through turbine and expanded there. Thus, turbine yields positive work which is used for driving compressor. Expanding gases leaving turbine are passed through exit nozzle where it is further expanded and results in high velocity jet at exit. This high velocity jet leaving nozzle is responsible for getting desired thrust for propulsion.	**03**

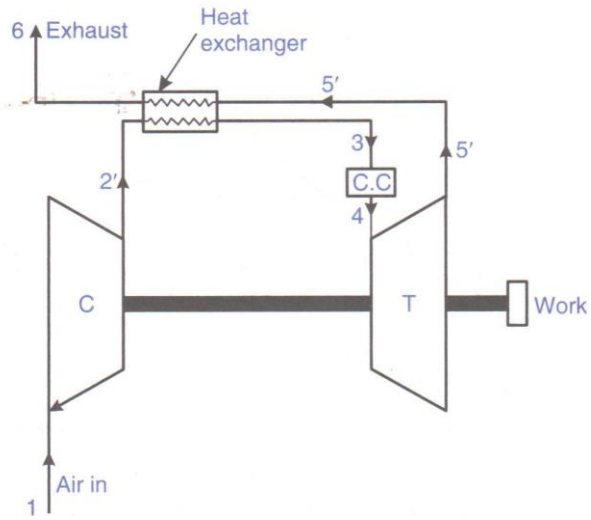
		 Turbojet engine differs from turboprop engine as turboprop is a jet engine with a properller attached to the front. The turbojet is the simplest form of the eingies. Turboprop uses propellers to produce more thrust. These are usually used on large cargo planes.	**03** **02**
Q.6		**Attempt any FOUR**	
	a	Function of different components in simple vapour absorption refrigeration system 1. **Generator** The generator is used to create the same task as of the compressor in the conventional compression refrigeration cycle. It is located where the heat is available from the exhaust gases, and the important limiting factor is the space occupied by generator. The generator used to evaporate the mixture of ammonia that react with water and leaves pure ammonia or mixture with high ammonia concentration. 2. **Absorber:** The absorber is a sort of vessel consisting of water that acts as the absorbent, and the previous absorbed refrigerant. Thus the absorber consists of the weak solution of the refrigerant (ammonia in this case) and absorbent (water in this case). When ammonia from the evaporator enters the absorber, it is absorbed by the absorbent due to which the pressure inside the absorber reduces further leading to more flow of the refrigerant from the evaporator to the absorber. 3. **Pump:** To transfer strong solution of aqua ammonia from absorber to generator. 4. **Pressure reducing valve**: When the refrigerant passes through the expansion valve, its pressure and temperature reduces suddenly. This refrigerant (ammonia in this case) then enters the evaporator.	**01 for each**
	b	**Following are the advantages of multi staging of compressor – (Any four)** 1) Reduced work of compression per kg of refrigerant 2) Wall thickness of L.P. cylinder is reduced, since it has to withstand lower pressures. This makes compressor lighter and cheaper. 3) Volumetric efficiency of compressor increases due to reduced pressure ratio in each stage.	**01 for each Any four**

		4) Temperature at end of compression would be less. As a result lubrication would be effective. Hence, compressor life increases. 5) Leakages past the piston are reduced 6) Operating cost is reduced 7) It gives more uniform torque; hence size of flywheel is reduced.	
	c	Q6 (c) Compression Ratio $\varepsilon = 1 + \frac{V_s}{V_c}$ $= 1 + \frac{0.12}{0.03}$ $= 5$ — (2) $\eta_{air\ std.} = 1 - \frac{1}{\varepsilon^{\gamma-1}}$ $= 1 - \frac{1}{5^{1.4-1}}$ $= 47.46\%$ — (2)	**04**
	d	**Air conditioning:** **Air conditioning** is the simultaneous control of temperature, humidity, motion and purity of the atmosphere in confined space. **Air conditioning systems are classified as** **1) Classification as to major function-** i) Comfort air-conditioning - air conditioning in hotels, homes, offices etc. ii) Commercial air-conditioning- air conditioning for malls, super market etc ii) Industrial air-conditioning – air conditioning for processing, laboratories etc **2) Classification as to season of the year-** i) Summer air-conditioning - These system control all the four atmospheric conditions for summer comfort. ii) Winter air-conditioning – This system is designed for comfort in winter. iii) Year round air-conditioning – These system consists of heating and cooling equipment's with automatic control to produce comfortable condition throughout the year	**01** **03**

3) Classification as to Equipment Arrangement-

i) Unitary system ii) Central system

e **Constant pressure open cycle gas turbine with regeneration**: The exhaust gases from the gas turbine carry a large quantity of heat with them since their temperature is far above the ambient temperature. They can be used to heat the air coming from the compressor thereby reducing the mass of fuel supplied in the combustion chamber. Figure shows a open cycle gas turbine with regeneration. **02**



Constant pressure open cycle gas turbine with intercooling: A compressor in a gas turbine utilizes a major portion of power developed. The work required by the compressor can be reduced by compressing the air in two stages and incorporating an intercooler between the two as shown in the figure. This process is called as intercooling **02**