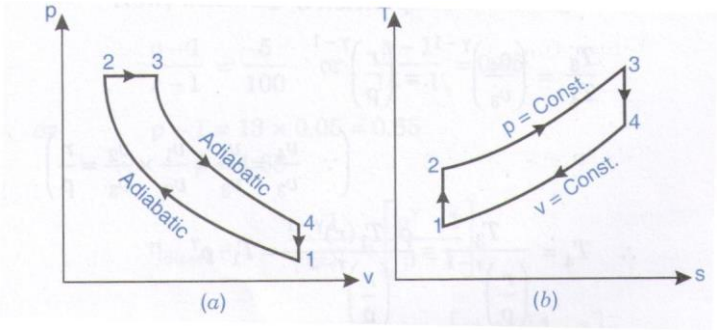
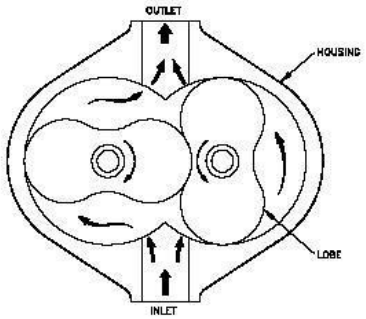
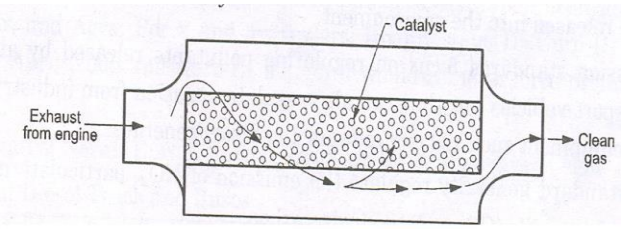
nImportant Instructions to examiners:

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. No.	Answer	Marking Scheme
1.A		**Attempt any THREE**	
	a)	**Diesel Cycle on P-V and T-S diagram** :  **Processes :** 1-2 : Isentropic compression 2-3 : Heat addition at constant pressure 3-3 Isentropic expansion 4-1 Heat rejection at constant volume	**Fig. 3 Marks 1M for processes**
	b)	**i) Brake thermal efficiency** – It is defined as the ratio of heat equivalent to brake power per unit time to the heat supplied to the engine per unit time Brake thermal efficiency = B.P./ m_f x C.V.	2M EACH

		ii) BSFC – It is the mass of fuel required to develop 1 kW brake power for a period of one hour. It is inversely proportional to the brake thermal efficiency. BSFC = Mass of fuel consumed in kg/hr / Brake power in kW	
	c)	**Classification of Air compressors**: **1. According to principle:** a. Reciprocating air compressors b. Rotary air compressors **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. Chain drive air compressors	**1 mark each**
	d)	**Rotary Lobe type Air Compressor** has two mating lobe-type rotors mounted in a case. The lobes are gear driven at close clearance, but without metal-to-metal contact. The suction to the unit is located where the cavity made by the lobes is largest. As the lobes rotate, the cavity size is reduced, causing compression of the vapor(air) within. The compression continues until the discharge port is reached, at which point the vapor exits the compressor at a higher pressure.  	2M 2M

1.B		Attempt any ONE	
	a)	**Methods to determine the frictional power of I.C. engine are`** 1. Willan's line method 2. Morse test 3. Motoring test 4. Difference between i.p. and b.p. ***Explanation of any one method***	2M 4M
	b)	**Catalytic converter:**  Catalytic converter is a device which converts harmful pollutants to harmless gases. Catalytic converter is used in exhaust emission in control system to convert CO, NO_x, HC and other harmful gases to harmless gases. A Catalytic converter consists of a cylindrical unit of small size like a small silencer and is installed into the exhaust system of a vehicle. It is placed between the exhaust manifold and the silencer. Inside the cylindrical tube i.e. converter there is a honey comb structure of a 'ceramic or metal' which is coated with 'alumina base' material and there after a second coating of precious metals 'platinum, palladium or rhodium' or combination of the same. This second coating serves as a catalyst. A catalyst is a substance which causes a chemical reaction intro the gases. When the exhaust gases pass over the converter substance, the toxic gases as CO, HC & NO_x are converted into harmless gases as CO_2, H_2 & N_2.	2M 4M

2		**Attempt any TWO**	
	a)	Q2 (a) Given, $d = 15\,cm \quad l = 25\,cm \quad P_m = 7.35\,bar \quad N = 400\,r.p.m.$ $T = 225\,N.m \quad m_f = 3\,kg/hr \quad C.V. = 44,200\,kJ/kg$ $b.p. = 2\pi NT$ $= 2\pi \times \frac{400}{60} \times 225$ $= 9428.57\,W = 9.429\,kW$ — (2m) $I.p. = P_m \cdot L \cdot A \cdot \frac{N}{n}$ $n = 2$ for four stroke $= 7.35 \times 10^5 \times (0.25) \times \frac{\pi}{4}(0.15)^2 \times \frac{400}{2 \times 60}$ $= 10828.12\,W = 10.828\,kW$ — (2m) $\eta_{mech} = \frac{b.p.}{I.p.} = \frac{9.429}{10.828} = 87\%$ — (1m) $\eta_{BTh} = \frac{b.p.}{m_f \times C.V.} = \frac{9.429}{\frac{3}{3600} \times 44,200}$ — (1m) $= 25.6\%$ $\eta_{Fth} = B.S.f.c. = \frac{m_f}{b.p.}$ $= \frac{3}{9.429}$ $= 0.3182\,kg/kW\text{-}hr$ $= 318.2\,gm/kW\text{-}hr$ — (2m)	**8 marks**
	b)	In single stage reciprocating air compressor, the entire compression is carried out in a single cylinder. The opening & closing of a simple check valve (plate or spring valve) depends upon the difference in pressure, if mechanically operated valves are used for suction & discharge then their functioning is controlled by cams. The weight of air in the cylinder will be zero when the piston is at top	**Working 4M**

dead centre. At this position, you have to neglect clearance volume.

When piston starts moving downwards, the pressure inside the cylinder falls below atmospheric pressure& suction valve/inlet valve opens.

The air is drawn into the cylinder through a suction filter element. This operation is known as suction stroke.

When the piston moves upwards, compresses the air in cylinder & inlet valve closes when the pressure reaches atmospheric pressure.

Further compression follows as the piston moves towards the top of its stroke. Until when the pressure in the cylinder exceeds that in the receiver.

This is compression stroke of a compressor. At the end of this stroke discharge/delivery valve opens & air is delivered to a receiver.

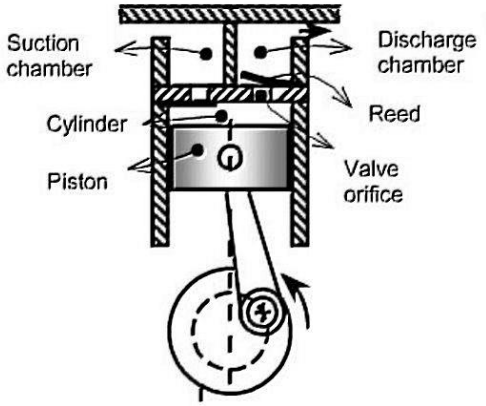
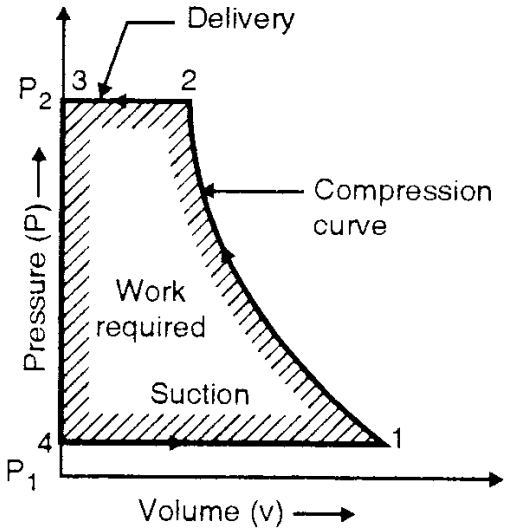
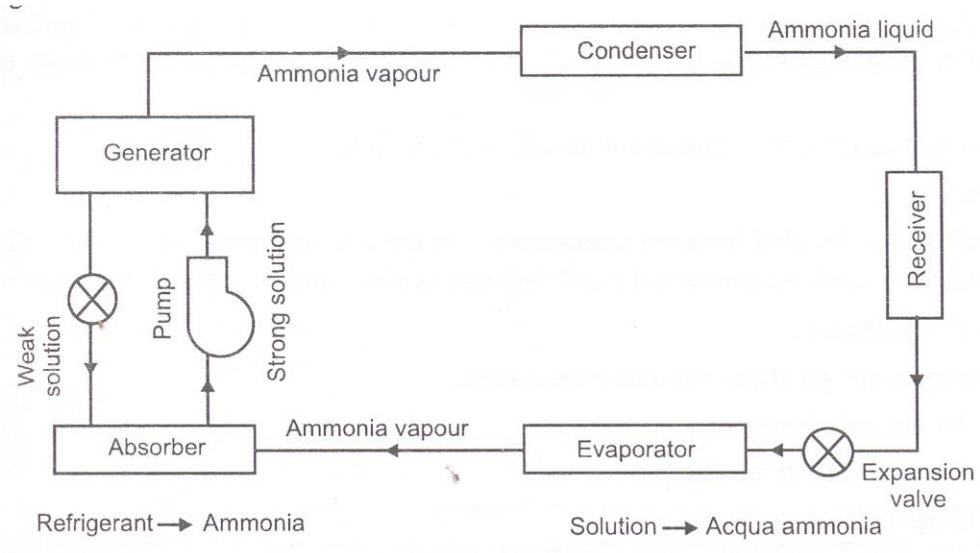
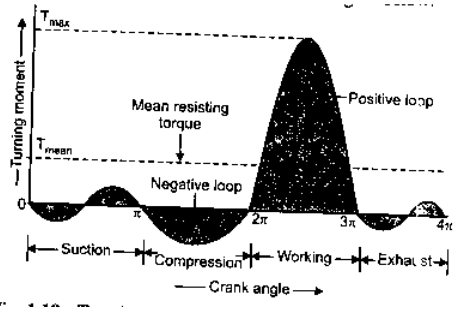


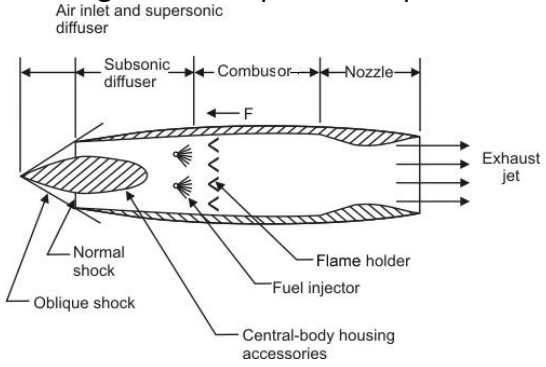
Fig. 2M

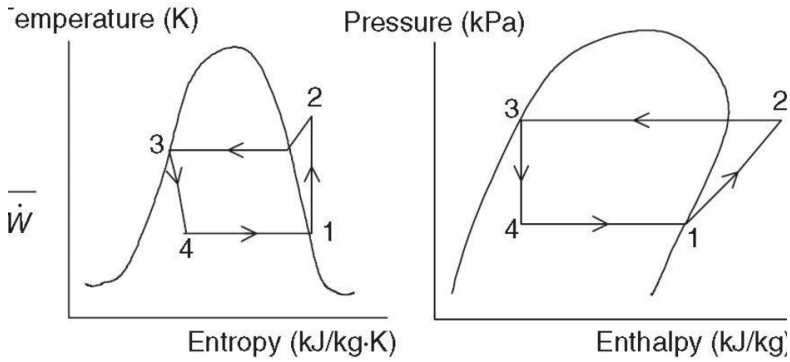
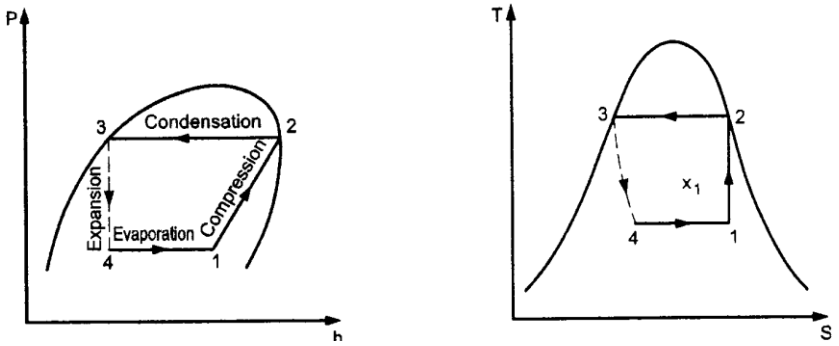


P – V Diagram 2M

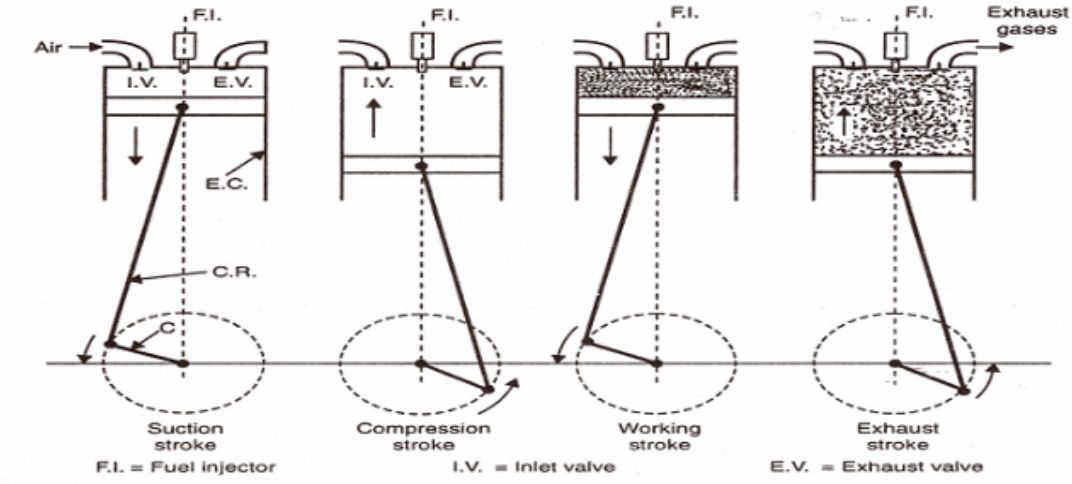
	C	**Working of Simple Vapor absorption system:** A Simple Vapor absorption system consists of evaporator, absorber, generator, condenser, expansion valve, pump & reducing valve. In this system ammonia is used as refrigerant and solution is used is aqua ammonia. Strong solution of aqua ammonia contains as much as ammonia as it can and weak solution contains less ammonia. The compressor of vapor compressor system is replaced by an absorber, generator, reducing valve and pump. The heat flow in the system at generator, and work is supplied to pump. Ammonia vapors coming out of evaporator are drawn in absorber. The weak solution containing very little ammonia is spread in absorber. The weak solution absorbs ammonia and gets converted into strong solution. This strong solution from absorber is pumped into generator. The addition of heat liberates ammonia vapor and solution gets converted into weak solution. The released vapor is passed to condenser and weak solution to absorber through a reducing valve. Thus, the function of a compressor is done by absorber, a generator, pump and reducing valve. The simple vapor compressor system is used where there is scarcity of Electricity and it is very useful at partial and full load. **------- 6 Marks** **Figure -2 Marks**  	

3	a)	**Turning moment diagram of four stroke engine:** **(sketch -2, explanation – 2 marks)**  During suction stroke, negative loop is formed as pressure inside engine cylinder is less than atmospheric pressure. During compression stroke, work is done on gases therefore higher negative loop is formed. During expansion or power stroke, fuel burn & gases expand therefore large positive loop is formed & during this stroke we get work output. During exhaust stroke, work is done on the gas to expel it out of cylinder, hence negative loop is formed.	
	b	Superchargers are pressure boosting devices (compressors) which increase the pressure of the air before inletting it get into cylinder of the internal combustion engine, and the process of increasing the pressure OR forcing more air to get into engine is called as supercharging. This gives each intake cycle of the engine more oxygen, letting it burn more fuel and do more work, thus increasing power. **Advantages** 1. Higher power output. 2. Reduced smoke from exhaust gases. The extra air pushed into cylinder, helps the air to complete combust leading to lesser smoke generation. 3. Quicker acceleration of vehicle. Supercharger starts working as soon as the engine starts running. This way the engine gets a boost even at the beginning leading to quicker acceleration. 4. Cheaper than turbocharger.	**02 M** **02 M**

	c)	The major air pollutants emitted by petrol engines are CO_2, CO, HC, NO_x, SO_2, smoke & lead vapour. **Effect of CO**: Carbon monoxide combines with hemoglobin forming carboy hemoglobin, which reduces oxygen carrying capacity of blood. 1. This leads to laziness, exhaustion of body & headache. 2. Prolong exposure can even leads to death. 3. It also affects cardiovascular system, thereby causing heart problem **Effect of CO_2**: Causes respiratory disorder & suffocation. **Effect of HC:** 1. It has effect like reduced visibility, eye irritation, peculiar odour & damage to vegetation & acceleration the cracking of rubber products. 2. 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.	**04 M**
	d)	Ramjet has no compressor as the entire compression depends upon compression. Function of supersonic & subsonic difference to convert the kinetic called the ram pressure. **Working:**- The air entering into ram jet with supersonic speed is slowed down to sonic velocity in the supersonic diffuser ,increasing air pressure. The air pressure is further increase in the subsonic diffuser increasing also the temperature of air. The diffuser section is designed to get correct ram effect. it's job is to decrease the velocity & increase pressure of incoming air. The fuel injected into combustion chamber is burned with help of flame igniter. The high pressure and high temperature gases are passed through the nozzle converting into pressure energy into kinetic energy. The high velocity gas leaving the nozzle provide required toward thrust to ramjet. 	**Working – 2 marks** **Fig.- 2 marks**

	e)	**Dry Compression**  **Wet Compression -**  	**02 M each**
4	**A**	**Attempt any THREE**	
	a)	**Effects of detonation** **(any four- 4 marks)** (1) **Noise** – As intensity of detonation increases, the sound intensity increases & it is harmful. (2) **Mechanical damage** – shock waves are so violent that it may cause mechanical damage like breaking of piston. It increases the rate of wear erosion of piston. (3) **Pre-ignition** – Due to local overheating of spark plug & this pre-ignition increases detonation. (4) **Power output & efficiency decreases** - Power output & thermal efficiency decreases due to abnormal combustion. (5) **Increase in heat transfer** – Temperature of cylinder in detonating engine is higher than in non – detonating engine, hence increases the heat transfer. (6) **Carbon deposits**- Detonation results in increased carbon deposits.	

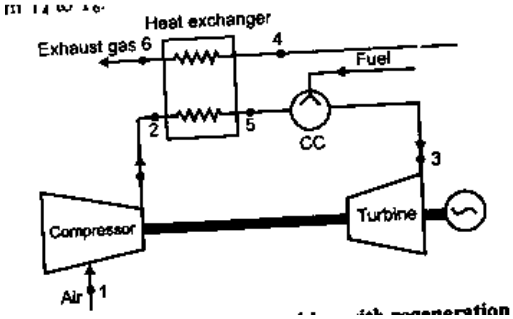
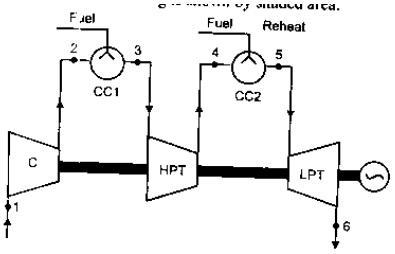
	b)	**i) Mechanical Efficiency-** It is the ratio of the power available at the engine crankshaft (bp) to the power developed in the engine cylinder (ip). **ii) Volumetric efficiency :-** It is the ratio of the actual volume of the charge admitted into the cylinder to the swept volume of the piston .	**2 marks each**
	c)	**Advantages of closed cycle gas turbine:** **(i)** It has higher thermal efficiency for the same minimum and maximum temperature limits and for the same pressure ratio. (ii) Since the heating is external, any kind of fuel even solid fuel having low calorific value may be used. (iii) There is no corrosion due to circulation of combustion product. (iv) As the system is a closed one there is no loss of the working fluid. (v) The size of the turbine will be smaller compared to an open cycle gas turbine of the same output. (vi) The regulation is more simple. (vii) The heat transmission coefficient in the exchanger is better due to the increase in suction pressure. (viii) Loss due to fluid friction is less due to higher Reynolds number.	**Any four advantages 1M each**
	d)	**Advantages of jet propulsion –** 1. Higher mechanical efficiency due to absence of reciprocating parts. 2. The weight of gas turbine per kW power developed is low since the working pressures are low requiring lighter construction. 3. Can produce much more power at much higher altitudes where drag is less so higher speeds are possible and they are more efficient. 4. Reliability is one of the elements of success for jet engines. They only have a couple of moving parts and almost no vibration.	

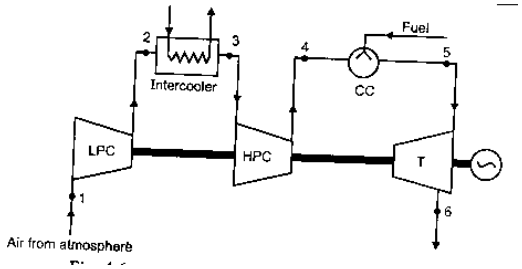
4	B	Attempt any ONE	
	a)	**Working of four stroke petrol engine**  1.**Intake Stroke**: As the name suggests in this stroke the intake of fuel takes place. When the engine starts, the piston descends to the cylinder's bottom from the top. Thus the pressure inside the cylinder reduces. Now the intake valve opens and the fuel and air mixture enters the cylinder. The valve then closes. 2.**Compression Stroke**: This stroke is known as compression stroke because the compression of the fuel mixture takes place at this stage. When the intake valve closes (exhaust valve is already closed), the piston forced back to the top of the cylinder and the fuel mixture gets compressed. 3.**Combustion/Power Stroke**: Now in case of petrol engine when the fuel mixture compresses to the maximum value the spark plug produces spark which ignites the fuel mixture. The combustion leads to the production of high pressure gases. Due to this tremendous force the piston is driven back to the bottom of the cylinder. As the piston moves downwards, the crankshaft rotates which rotates the wheels of the vehicle. 4.**Exhaust Stroke**: As the wheel moves to the bottom the exhaust valve opens up and due to the momentum gained by the wheel the piston is pushed back to the top of the cylinder. The gases due to combustion are hence expelled out of the cylinder into the atmosphere through the exhaust valve. The exhaust valve closes after the exhaust stroke and again the intake valve opens and the four strokes are repeated.	**02 M** **04 M**

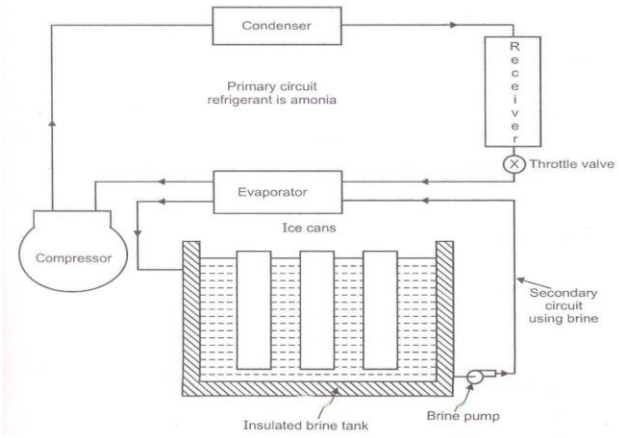
	b)	Q4. (B) b) B.P. with all cylinders working = 14.7 kW I.P. of first cylinder $I.P._1 = 14.7 - 10.14 = 4.56$ kW — " — second — " — $I.P._2 = 14.7 - 10.3 = 4.4$ kW — " — third — " — $I.P._3 = 14.7 - 10.36 = 4.34$ kW — " — Fourth — " — $I.P._4 = 14.7 - 10.21 = 4.49$ kW (1 mark each) Total I.P. $= I.P._1 + I.P._2 + I.P._3 + I.P._4$ $= 4.56 + 4.4 + 4.34 + 4.49$ $= 17.79$ kW — (1 marks) $\eta_{mech.} = \frac{B.P.}{I.P.} = \frac{14.7}{17.79} = 82.63\%$ — (1 marks)	
5	a)	**Attempt any TWO**	

i)

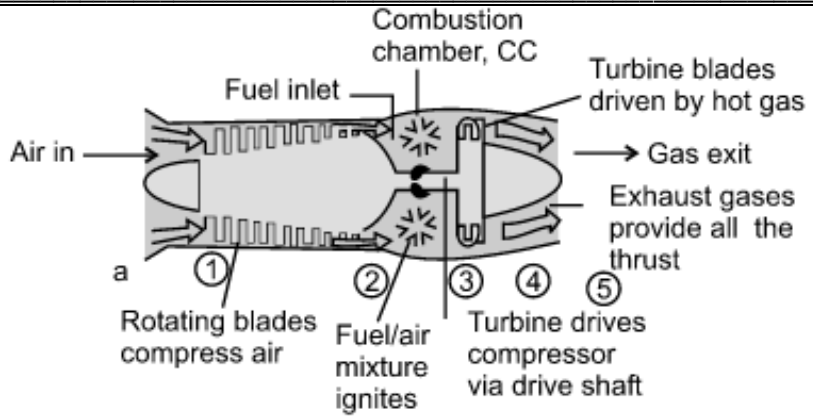
Reciprocating compressor	Rotary compressor	Any four points 01 M
1. Compression of air takes place with help of piston and cylinder arrangement with reciprocating motion of piston.	1. Compression of air takes place due to rotary motion of blades.	
2. Delivery of air intermittent.	2. Delivery of air is 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.	

	ii)	**Following are the applications of compressed air (Any Eight) 1/2 mark each** 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.	
	b)	**Methods to improve thermal efficiency of gas turbine** **(List of methods -3 marks, explanation of any one – 5 marks)** **1) Regeneration** – This is done by preheating the compressed air before entering to the combustion chamber with the turbine exhaust in a heat exchanger, thus saving fuel consumption.  **2) Reheating** : The whole expansion in the turbine is achieved in two or more stages & reheating is done after each stage. That increase in work done.  	

		3) Intercooling –The compression is performed in two or more stages. But between two stage there is intercooler where cooling takes place at constant pressure.To increase net work of gas turbine by saving some compression work.  	
	c)	**Working of Ice plant: (Explanation 05 marks ….fig 03 marks)** The main cycle used for ice plant is vapor compression cycle with ammonia as the refrigerant in primary circuit and brine solution in secondary circuit. Brine solution takes heat from water in secondary circuit and delivers the heat to ammonia in primary circuit. Thus, the indirect method of cooling is used in ice plant. In secondary circuit brine is cooled in evaporator and then it is circulated around the can which contains water. The heat is extracted from the water in the can and is given to the brine. The brine is contentiously circulated around the can with the help of brine pump till entire water in the can is converted into ice at -6^0 C. Ammonia vapor coming out of evaporator is compressed to high pressure and then these vapors are condensed in the condenser. High pressure liquid ammonia is collected in the receiver and it is passed through the expansion valve to reduce its pressure and temperature as per requirement. The throttle liquid ammonia at low temperature & low pressure enters in evaporator, which are the coils dipped in brine tank. The liquid ammonia absorbs heat from brine and gets converted into vapors, which are drawn by suction line of compressor.	

			
6		**Attempt any FOUR**	
	a)	**Following sensors are used in ECU: (Any 4 sensors…04 marks)** **Crank angle sensor:** A permanent magnet inductive signal generator is mounted in close proximity to the flywheel, where it radiates a magnetic field. As the flywheel spins and the pins are rotated in the magnetic field, an alternating (AC) waveform is delivered to the ECM to indicate speed of rotation. **Air Flow Sensor (AFS):** The AFS is normally located between the air filter and the throttle body. As air flows through the sensor, it deflects a vane (flap) which wipes a potentiometer resistance track and so varies the resistance of the track and generates a variable voltage signal. **Manifold absolute pressure (MAP) sensor:** The MAP sensor measures the manifold vacuum or pressure, and uses a transducer to convert the signal to an electrical signal which is returned to the ECM. The unit may be designed as an independent sensor that is located in the engine compartment or integral with the ECM. **Coolant temperature sensor (CTS):** The CTS is a two-wire thermistor that measures the coolant temperature. The CTS is immersed in the engine coolant, and contains a variable resistor that usually operates on the NTC principle. **Throttle Position Sensor (TPS):** TPS is provided to inform the ECM of idle position,	

		deceleration, rate of acceleration and wide-open throttle (WOT) conditions. The TPS is a potentiometer which varies the resistance and voltage of the signal returned to the ECM. **Oxygen sensor (OS):** An oxygen sensor is a ceramic device 'placed in the exhaust manifold on the engine side of the catalytic converter. The oxygen sensor returns a signal to the ECM, which can almost instantaneously (within 50 ms) adjust the injection duration.	
	b)	**i) Isothermal efficiency** – It is defined as the ratio of isothermal power to the indicated or actual power. Isothermal efficiency = Isothermal power / Indicated power **ii) Volumetric efficiency** – It is the ratio of actual volume of the free air delivered at standard atmospheric condition at discharge in one delivery stroke to the swept volume by the piston during the stroke.	**2 Marks each**
	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.	**02 M**



(**02 M**)

d)

i) DBT – Dry bulb temperature - t_{DB} - It is the temperature of air recorded by an ordinary thermometer and it is not affected by the moisture present in air.

ii) **WBT** -It is the temperature recorded by thermometer when its bulb is covered with wet cloth known as wick and is exposed to air.

iii) DPT – Dew point temperature t_{DP} *D.P.T. of mixture is defined as the temperature at which water vapours starts to condense.*

iv) Relative humidity:- It is defined as the ratio of partial pressure of water vapour in a given volume of mixture to the partial pressure of water vapour when same volume of mixture is saturated at the same temperature.

$$\therefore \text{RH} = \frac{P_V}{P_V sat} \times 100$$

01 M each

e)

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

iii) 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 equipments with automatic control to produce comfortable condition throughout the year 3)According to equipment arrangement-Unitary and Central air conditioning.

04 M