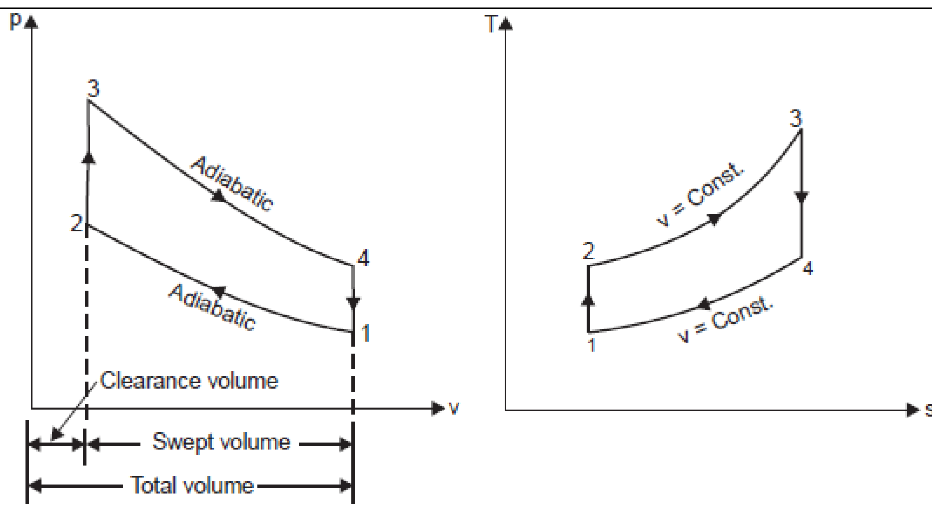
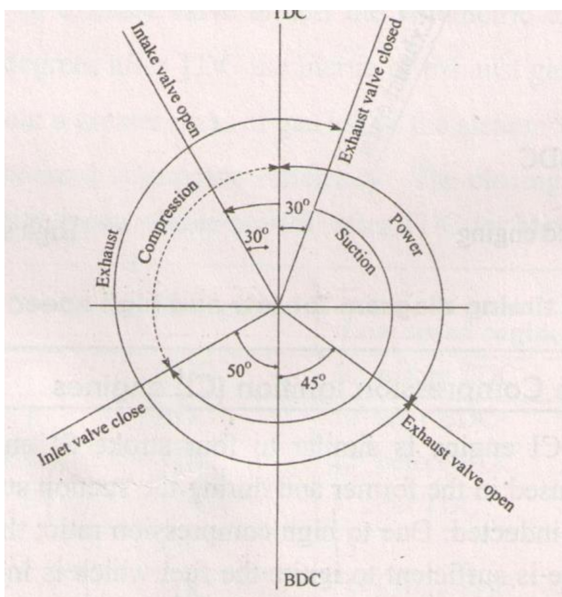
WINTER – 19 EXAMINATION

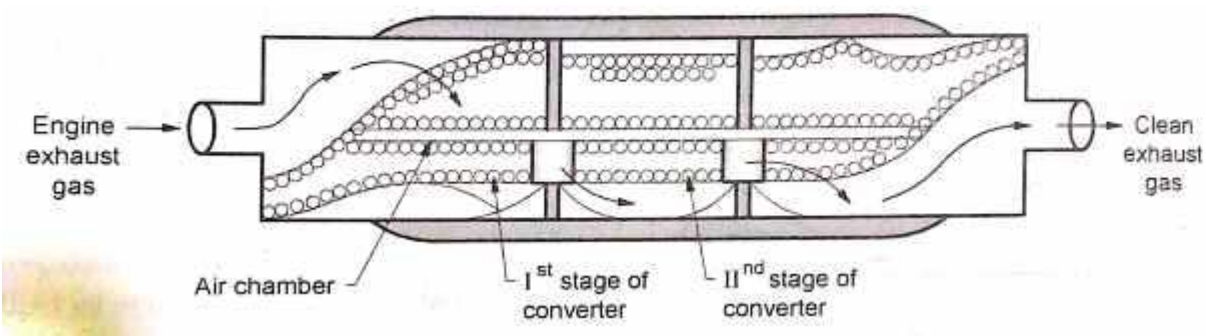
Subject Name: **Model Answer** Subject Code: 17529

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. No.	Sub Q.N.	Answer	Marking Scheme
Q.1 (A)	a)	 	3M
		1-2 is a adiabatic compression of air; there is no heat transfer during this process. 2-3 shows the supply of heat to the air at constant volume; during this heat is supplied 3-4 represents the adiabatic expansion of the air; no heat transfer 4-1 shows the rejection of heat by air at constant volume; heat is rejected.	1M
	b)	**i) Compression ratio** – It is defines as the ratio of the absolute discharge pressure to the absolute inlet pressure. It is the ratio of volume before compression to volume after compression. **ii) FAD:-** It is the volume of air delivered by compressor under the intake conditions of temperature and pressure. Capacity of compressor is generally given in terms of free air delivery. Unit = m^3/cycle	2M each

	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 ½ M each
	d)	**Valve timing diagram of four stroke diesel engine** 	4M
Q. 1 (B)	a)	Morse Test cannot be conducted for single cylinder engine Morse test is used to find a close estimate of indicated power of a multi cylinder engine. In this test the engine is coupled to a suitable brake dynamometer and the brake power is determined by running the engine at required speeds. Here the different engine speeds are obtained by interrupting the fuel supply in the constituent cylinders of the engine. Therefore in a multi cylinder engine if fuel supply is cut off in any of the cylinders, the other cylinders continue to run and as a result the output from the engine is obtained. But in case of a single cylinder engine if the fuel supply is cut off no output is obtained to conduct the performance test. Therefore, Morse test is not conducted for a single cylinder engine.	2M

		Motoring Test - 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 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.	**4M**
	b)	A catalytic converter is a device which reduces pollutants like HC, CO and NO_x . 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 CO_2 and HC to H_2O and CO_2 and reduce NO_x to N_2 . The catalyst themselves do not participate in the reaction The front part of the catalyst is for NO_x reduction and rear part is for CO and HC oxidation.  **Figure: Three way catalytic converter**	4M 2M for figure
Q.2	a)	Rotary Lobe type Air Compressor consists of two motor rotors driven externally. One of the rotors is connected to the drive and the second one is gear driven from the first. The rotors have two or three lobes having cycloid, hypocycloid, involutes shape profile. The high pressure delivery side is sealed from low pressure suction side at all angular position. 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 air within. The compression continues until the discharge port is reached, at which point the air exits the compressor at a higher pressure. The delivery of air into the receiver is not continuously even though the rotor revolves with uniform speed.	6M

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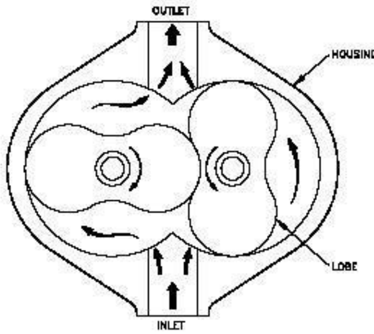
<tr><td></td><td></td><td>

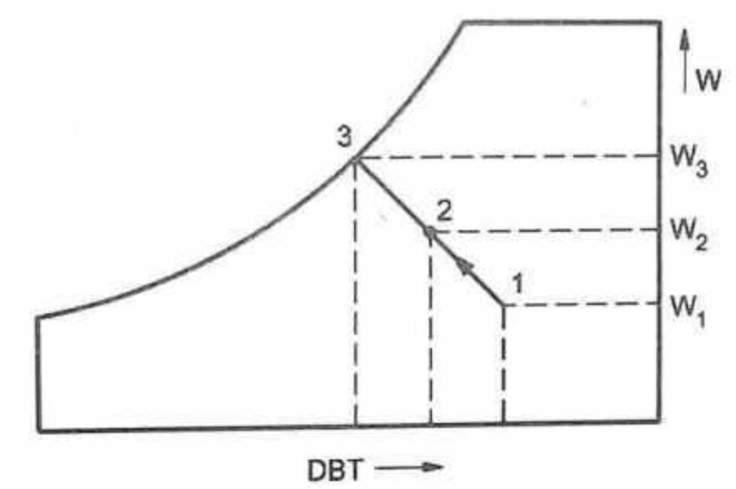
Figure: Rotory Lobe type Air Compressor</td><td>2M</td></tr>
<tr><td></td><td>b)</td><td>Following are the processes on psychrometric chart:
(1) Evaporative cooling


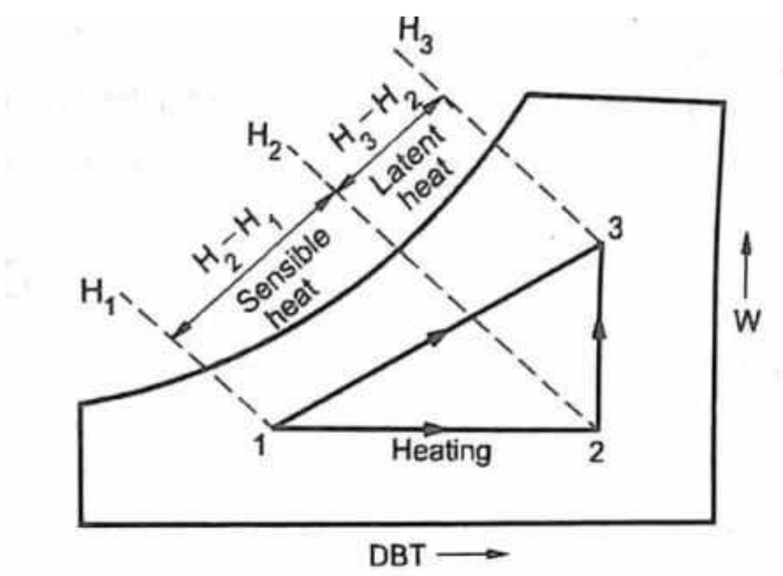
Figure: Evaporative cooling
(2) Heating with humidification


Figure: Heating with humidification</td><td>2M

2M</td></tr>
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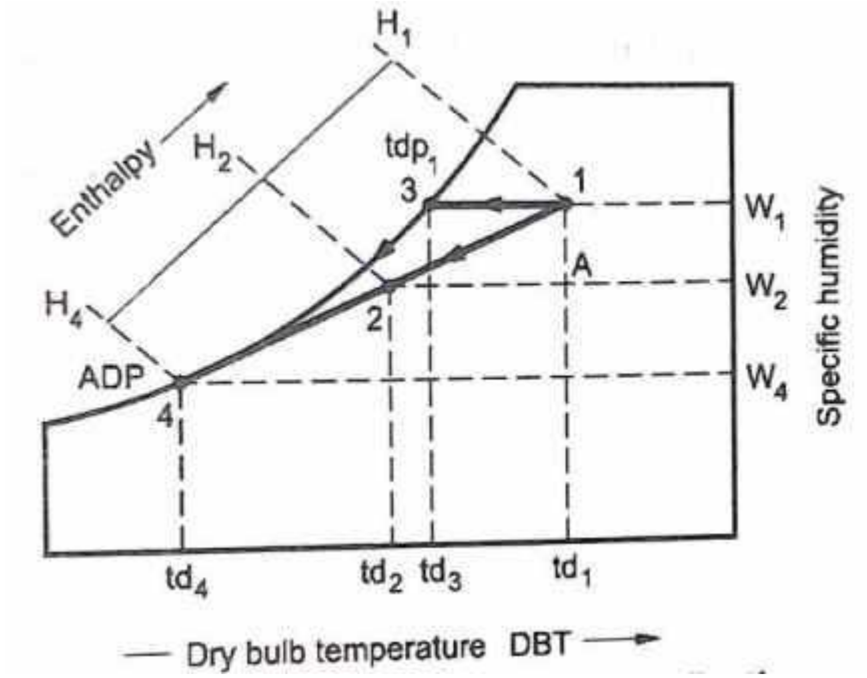
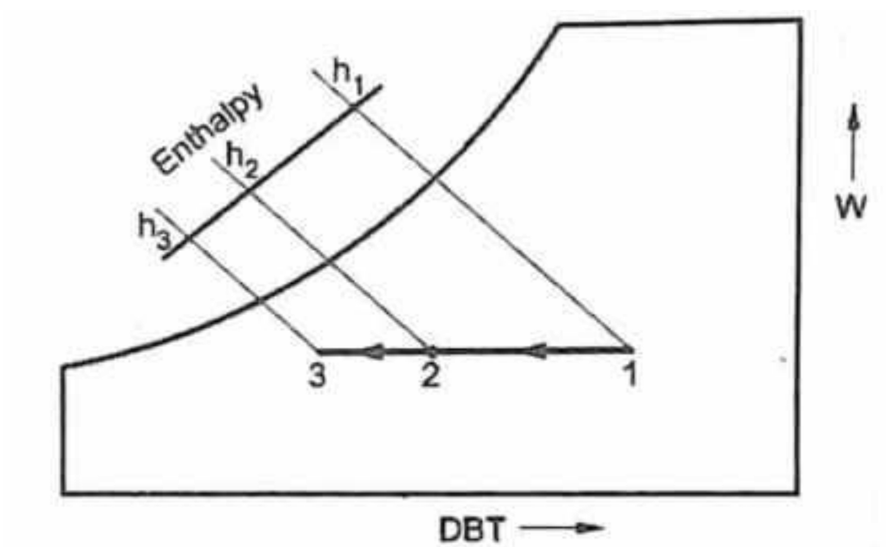
		(3) Cooling with dehumidification  **Figure: Cooling with dehumidification** (4) Sensible cooling  **Figure: Sensible Cooling**	2M 2M

c)

Q2 (c) B.P. = 30 kW N = 2500 RPM

P_m = 800 kN/m² η_{mech} = 80%

$\frac{L}{d} = 1.5$ No. of cylinders = 4

η_{bth} = 28% C.V. = 44,000 kJ/kg

$$I.P. = \frac{B.P.}{\eta_{mech.}} = \frac{30}{0.8} = 37.5\ kW \quad — (1)$$

$$I.P./cylinder = \frac{37.5}{4} = 9.375\ kW \quad — (1)$$

$$I.P./cylinder = P_m \cdot L \cdot A \cdot N$$

$$9.375 = \frac{800 \times 10^3 \times 1.5d \times \pi \times d^2 \times 2500}{4 \times 60 \times 1000}$$

$$d = 0.062\ m = 6.2\ cm \quad — (2)$$

$$L = 1.5d = 1.5 \times 6.2 = 9.3\ cm \quad — (1)$$

$$\eta_{Bth} = \frac{B.P.}{m_f \times C.V.}$$

$$B.S.F.C. = \frac{m_f}{B.P.} = \frac{3600}{0.28 \times 44,000}$$

$$= 0.2922\ kg/kW\text{-}h \quad — (3)$$

Q.3 a)

The major air pollutants emitted by petrol & diesel engines are CO_2, CO, HC, NO_x, SO_2, smoke & lead vapour.

(Each For 1M)

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

b)

Sr. No.	Factors	Open cycle gas turbine	Closed cycle gas turbine
1.	**Pressure**	Lesser pressure	Higher pressure
2.	**Size of the plant for given output**	Larger size	Reduced size
3.	**Output**	Lesser output	Greater output
4.	**Corrosion of turbine blades**	Corrosion takes place due to contaminated gases	No corrosion since there is indirect heating.
5.	**Working medium**	Loss of working medium	No loss of working medium.
6.	**Filtration of incoming air**	It may cause severe problem.	No filtration of air is required.
7.	**Part load efficiency**	Less part load efficiency	More part load efficiency
8.	**Thermal efficiency**	Less thermal efficiency	More thermal efficiency
9.	**Requirement of cooling water**	No Requirement of cooling water	Larger amount of cooling water required
10.	**Weight of system for given power**	Less	More
11.	**Response to the changing load**	Good response	Poor response
12.	**Fluid friction**	More Fluid friction	Less Fluid friction

Any Eight points ½ M each

c)

(i) One ton of refrigeration:

A ton is of refrigeration is defined as "the quantity of heat required to remove from one ton of ice within 24 hours when initial condition of water is 0^0C ", because the same cooling effect will be given by melting the same ice.

2M

1 ton of refrigeration =1000 X Latent heat of ice/24

= 1000 X 335/(24 X 60)

= 232.6 kJ/min

= 3.516 kJ/S or KW

In actual practice, one tone of refrigeration is taken as equivalent to 3.516 kW.

2M

(ii) Coefficient of performance:
The performance of a refrigeration system is expressed by a term known as the ‘‘co-efficient of performance or **COP**’’: It is defined as the ratio of heat absorbed by the refrigerant while passing through the evaporator to the work input required to compress the refrigerant in the compressor ; in short it is the ratio between heat extracted and work done.
C.O.P. of refrigerator = Heat absorbed / Work done

d)

(List of methods -1 mark, explanation of any one with fig. – 3 marks)

Following methods are used for improving thermal efficiency of gas turbine

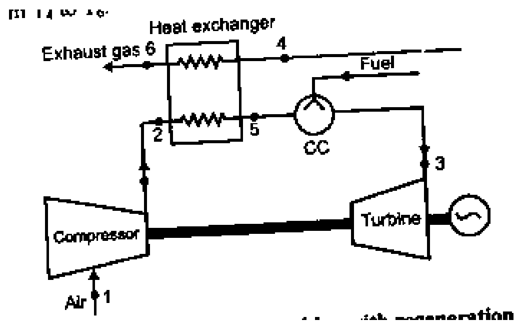
Methods -1M

1) Regeneration **2) Reheating** : **3) Intercooling**

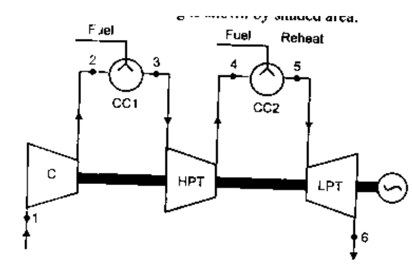
1) Regeneration – This is done by preheating the compressed air before entering to the combustion chamber with the turbine exhaust in a heat exchanger, thus saving fuel consumption.

Figure-1M

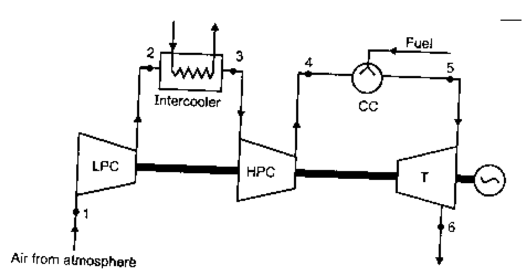
Explanation-2M

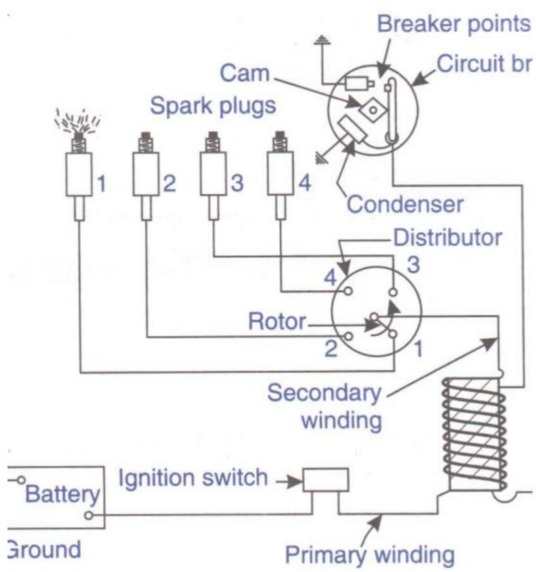


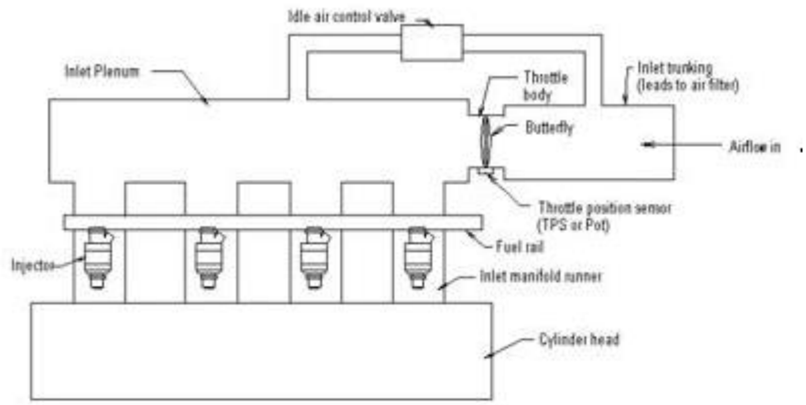
2) Reheating : The whole expansion in the turbine is achieved in two or more stages & reheating is done after each stage.

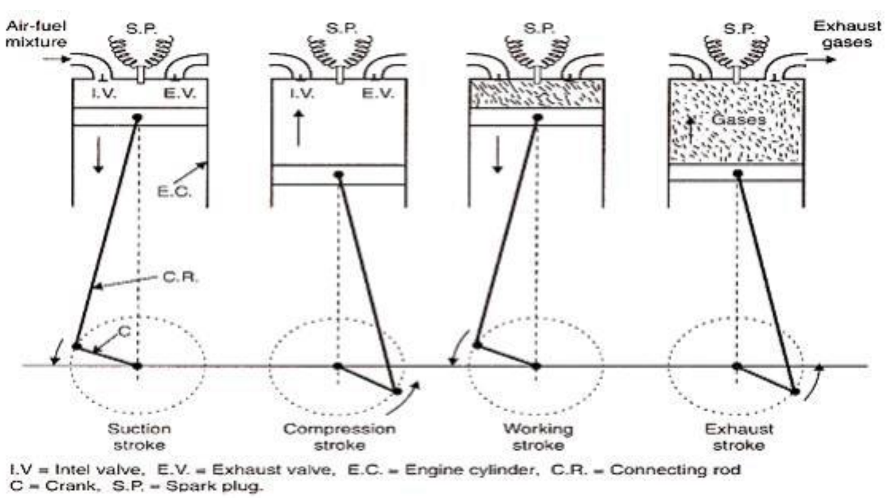


3) Intercooling –The compression is performed in two or more stages. But between two stage there is intercooler where cooling takes place at constant pressure.

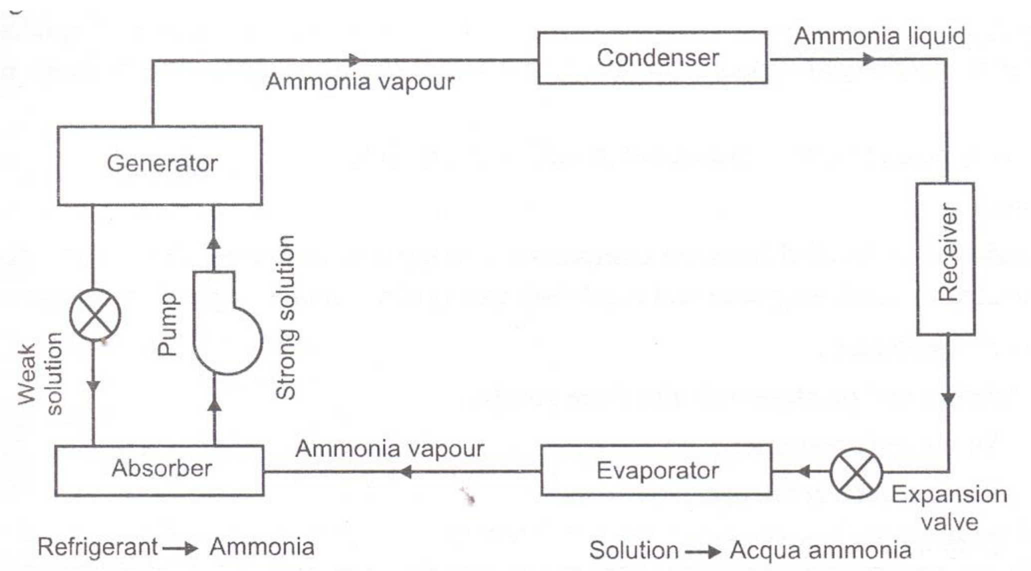


	e)	Battery Ignition system: It consists of a battery of 6 or 12 volts, ignition switch, induction coil, condenser, distributor and a circuit breaker. One terminal of battery is ground to the frame of the engine and other is connected through the ignition switch to one primary terminal of the ignition coil. The other terminal is connected to one end of contact points of the circuit breaker. To start with the ignition switch is made on and the engine is cranked. The contacts touch, the current flows from battery through the switch. A condenser connected across the terminals of the contact breaker points prevent the sparking at these points. The rotating cam breaks open the contacts immediately and breaking of this primary circuit brings about a change in the magnetic fields and voltage changes from 12 to 12000 V. due to the high voltage. The spark jumps across the gap in the spark plug and air fuel mixture is ignited in the cylinder  **Figure: Battery ignition in S.I. engine**	2M 2M
Q.4	a)	There are basically three types of MPFI systems. 1. Sequential multi point fuel injection system 2. Simultaneous multi point fuel injection system 3. Batched multi point fuel injection system In the sequential MPFI system, injection is timed to overlap with intake stroke of each cylinder. In the simultaneous MPFI system, fuel is inserted to all cylinders at the same time. In the batched MPFI system, fuel is injected to the cylinders without bringing their intake stroke together. MPFI includes a fuel pressure regulator, fuel injectors, cylinders, pressure spring and a control diaphragm. It uses multiple individual injectors to insert fuel in each cylinder through intake port situated upstream of cylinder's intake value. The fuel pressure regulator, connected to the fuel rail by means of an inlet and outlet, directs the flow of the fuel. While the control diaphragm and pressure spring controls the outlet valve opening and the amount of fuel that can return. The pressure in the intake manifold significantly changes with the engine speed and load.	2M 2M

		 **Figure: MPFI**	
	b)	**i) Indicated Power (I.P):** The total power developed by combustion of fuel in the combustion chamber is called indicated power. **ii) Mechanical Efficiency-** It is the ratio of the power available at the engine crankshaft (B.P.) to the power developed in the engine cylinder (I.P.). **Mechanical Efficiency = Brake Power (B.P.)/ Indicated Power (I.P)** **iii) Brake Power (B.P.)**: The power developed by an engine at the output shaft is called brake power. **iv) Break Specific Fuel Consumption** (**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	1M each
	c)	**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. Types – 1. Cross flow scavenging 2. Full loop or backflow scavenging 3. Uniform flow scavenging	2M 2M

	d)	Q4 (d) B.P. with all cylinder working = 18.6 kW $I.P._1 = (B.P.)_{\text{all cylinder working}} - (B.P.)_{2,3,4}$ $= 18.6 - 13.2 = 5.4$ kW $I.P._2 = 18.6 - 13.34 = 5.26$ kW $I.P._3 = 18.6 - 13.58 = 5.02$ kW $I.P._4 = 18.6 - 13.27 = 5.33$ kW — (2) marks Total $I.P. = I.P._1 + I.P._2 + I.P._3 + I.P._4$ $= 5.4 + 5.26 + 5.02 + 5.33$ $= 21.01$ kW — (1) $\eta_{mech.} = \frac{B.P.}{I.P.}$ $= \frac{18.6}{21.01} = 88.52\%$ — (1)	
B)	a)	**Explain four strokes of SI engine**  **Figure: Four stroke petrol engine**	2M

		Working of Four stroke petrol engine 1. **Suction stroke**: Suction stroke starts when piston is at top dead center and about to move downwards. During suction stroke inlet valve is open and exhaust valve is closed. Due to low pressure created by the motion of the piston towards bottom dead center, the charge consisting of fresh air mixed with the fuel is drawn into cylinder. At the end of suction stroke the inlet valve closes. The suction stroke is shown in fig 2. **Compression stroke**: During compression stroke, the compression of charge takes place by return stroke of piston, i.e. when piston moves from BDC to TDC. During this stroke both, inlet and exhaust valve remain closed. Charge which is occupied by the whole cylinder volume is compressed up to the clearance volume. Just before completion of compression stroke, a spark is produced by the spark plug and fuel is ignited. Combustion takes place when the piston is almost at TDC. The Compression stroke is shown in fig 3**. Expansion or power stroke**: piston gets downward thrust by explosion of charge. Due to high pressure of burnt gases, piston moves downwards to the BDC. During expansion stroke both inlet and exhaust valves remains closed as shown in fig . Thus power is obtained by expansion of products of combustion. Therefore it is also called as 'power stroke'. Both pressure as well as temperature decreases during expansion stroke. 4**. Exhaust stroke**: At the end of expansion stroke the exhaust valve opens, the inlet valve remains closed and the piston moves from BDC to TDC as shown in fig. During exhaust stroke the burnt gases inside the cylinder are expelled out. The exhaust valve closes at the end of the exhaust stroke but still some residual gases remains in cylinder.	4M
	b)	**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	Any Six 1M Each
Q.5	a)	**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	6M

		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.  **Figure: Vapour absorbtion system**	2M

	b)	Q5 (b) Intermediate pressure when inter cooling is perfect $P_2 = \sqrt{P_1 \cdot P_3} = \sqrt{1 \times 10} = 3.16$ bar — (1) Power required to drive the compressor $= \frac{2n}{n-1} P_1 V_1 \left[\left(\frac{P_3}{P_1} \right)^{\frac{n-1}{2n}} - 1 \right]$ $= \frac{2 \times 1.25}{1.25-1} \times 1 \times 10^5 \times \frac{2}{60} \left[\left(\frac{10}{1} \right)^{\frac{1.25-1}{1.25 \times 2}} - 1 \right]$ $= 33,333.33 \, [0.2589]$ $= 8630.846$ W $= 8.631$ kW — (2) In case of single stage compression $W_1 = \frac{n}{n-1} P_1 V_1 \left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right]$ $= \frac{1.25}{1.25-1} \times 1 \times 10^5 \times 2 \left[\left(\frac{10}{1} \right)^{\frac{1.25-1}{1.25}} - 1 \right]$ $= 10,00,000 \, [0.5848]$ — (2) $= 584800$ N-m/cycle In case of two stage compression $W_2 = 8630.846 \times 60 = 517850.76$ N-m/cycle — (1) % Saving in work $= \frac{W_1 - W_2}{W_1}$ $= \frac{584800 - 517850}{584800}$ $= 0.114 = 11.4\%$ — (2)	

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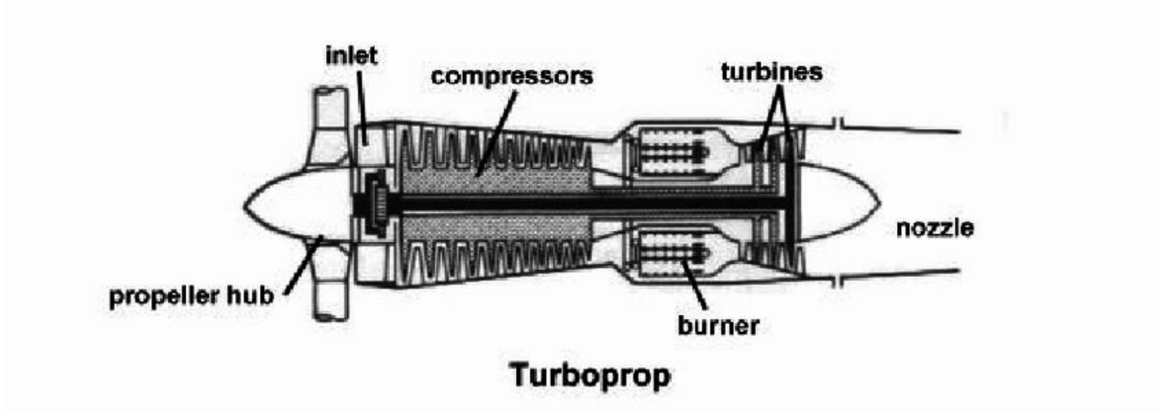

Figure: Turbo propeller engine

A turboprop engine is a turbine engine that drives an aircraft propeller. In its simplest form a turboprop consists of an intake, compressor, combustor, turbine, and a propelling nozzle. Air is drawn into the intake and compressed by the compressor. Fuel is then added to the compressed air in the combustor, where the fuel-air mixture then combusts.

The hot combustion gases expand through the turbine. Some of the power generated by the turbine is used to drive the compressor. The rest is transmitted through the reduction gearing to the propeller. Further expansion of the gases occurs in the propelling nozzle, where the gases exhaust to atmospheric pressure.

The propelling nozzle provides a relatively small proportion of the thrust generated by a turboprop. In contrast to a turbojet, the engine's exhaust gases do not generally contain enough energy to create significant thrust, since almost all of the engine's power is used to drive the propeller.

Advantages:

1. In dense air, i.e. lower levels, a propeller has a higher efficiency than ram jet
2. Generally turboprop aircraft can operate into shorter runways than jets
3. The propeller can be feathered to minimize drag in the event of engine failure, which is not possible for ram jet.

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4M

2M</td></tr>
<tr><td>Q.6</td><td>a)</td><td>

Vapour Compression Refrigeration Cycle

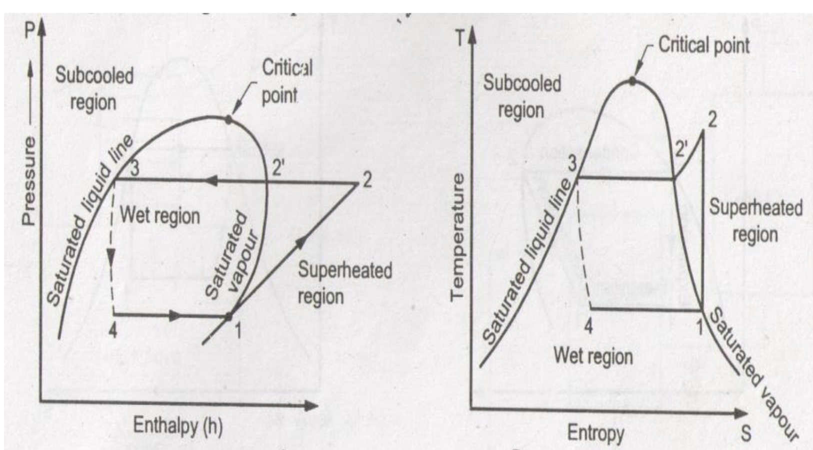

Figure: P-H and T-S representation of simple vapour compression refrigeration cycle

The P-H and T-S diagram for the simple vapor compression refrigeration cycle is shown in the figure for vapour entering the compressor is in dry saturation condition.

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each</td></tr>
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	b)	**Following are the uses 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 Four uses 1M each
	c)	Q6 (c) $P_1 = 1.4\ bar \quad T_1 = 25^\circ C = 298^\circ K$ $P_2 = 10\ bar$ $P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$ $\frac{V_1}{V_2} = \left(\frac{P_2}{P_1}\right)^{1/\gamma} = \left(\frac{10}{1.4}\right)^{1/1.4}$ $= (7.14)^{0.714} = 4.07$ ← (2) Compression Ratio $= r_c = 4.07$ $\eta_{air\ std.} = 1 - \frac{1}{r_c^{\gamma-1}} = 1 - \frac{1}{4.07^{1.4-1}}$ $= 1 - 0.57 = 0.43 = 43\%$ (2)	

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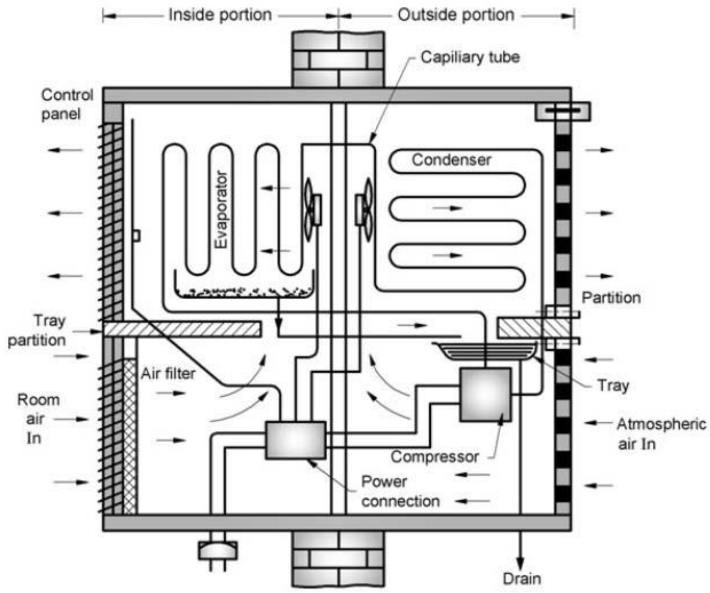
<td>d)</td>
<td>Draw a neat sketch of window air conditioner and label the parts


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<td>2M for figure

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<td>e)</td>
<td>Reheating: Figure shows gas turbine unit reheating arrangement for improvement in its efficiency. The output of a gas turbine can be amply improved by expanding the gases in two stages with a re-heater between the two as shown in Fig. The H.P. turbine drives the compressor and the L.P. turbine provides the useful power output. The corresponding T-s diagram is shown in Fig. following are important processes:

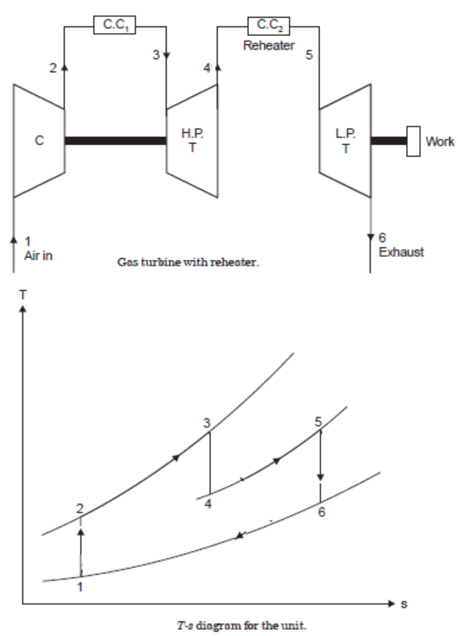
Process 1-2: Isentropic Compression
Process 2-3: Heat addition CC1
Process 3-4: Isentropic Expansion in HP turbine
Process 4-5: Heat addition in CC2
Process 5-6: Isentropic Expansion in LP turbine


Figure: Reheating
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