WINTER – 19 EXAMINATION

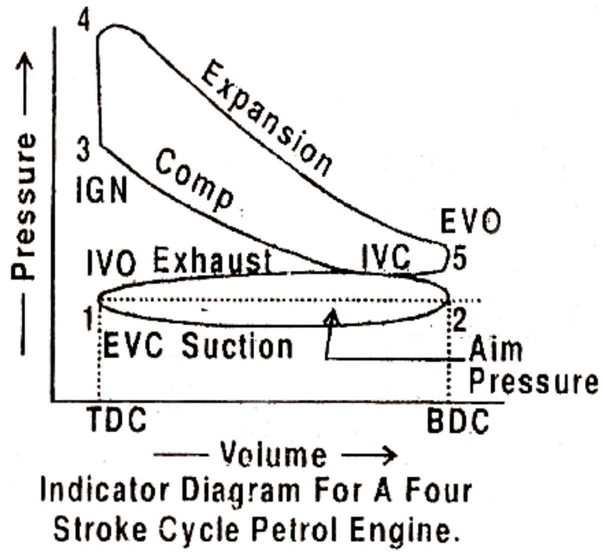
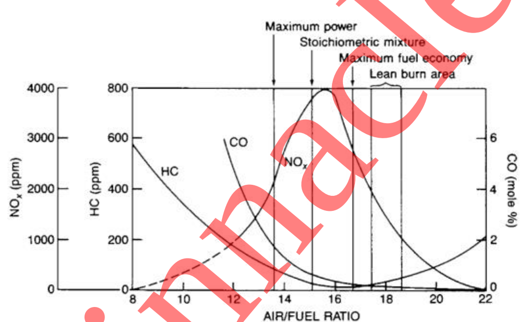
Subject Name: Power Engg. & Refrigeration **Model Answer** Subject Code: 22562

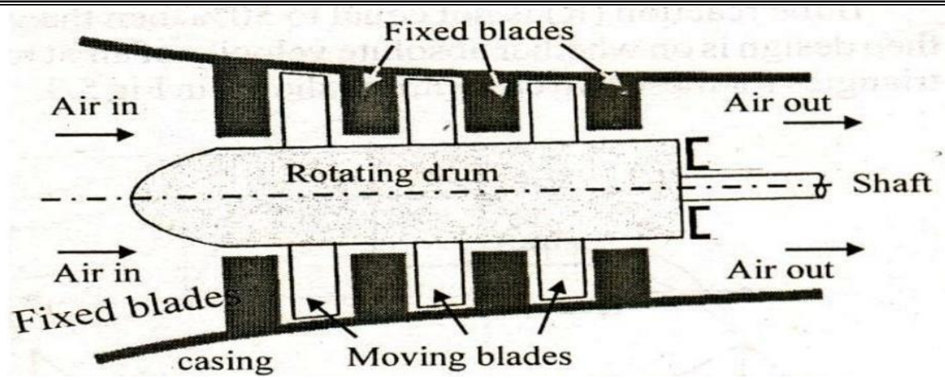
Important Instructions to examiners:

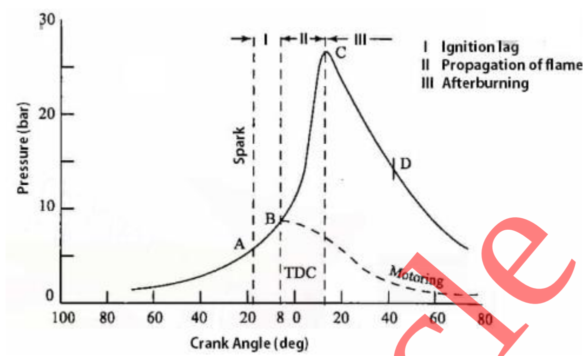
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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)	Following are the diagnostic tools used in fault finding of MPFI engines 1. Engine Code Readers 2. Compression Testers 3. Spark Plug Testers **4.** Mechanic's Stethoscope 5. Scan Tool 6. Battery Tester 7. Power Probe III	**Any 4** **2M**
	b)	SEER: Seasonal Energy Efficiency Ratio (**SEER**), is most commonly used to measure the efficiency of a central air conditioner. The higher the SEER, the more efficient the system OR It is the ratio of cooling Capacity to energy consumed in watts-hours. EER: Energy Efficiency Ratio (**EER**) is a measure of how efficiently a cooling system will operate when the outdoor temperature is at a specific level (95 degrees F). The higher the EER, the more efficient the system. In technical terms,(Correction) OR It is the ratio of total capacity to the total KW energy usage at specific humidity and temperature condition.	1M each
	c)	Purpose of Selective Catalytic Reduction (SCR) : 1. It reduces Nox 75% to 90% 2. Converts it in to molecular nitrogen and water vapor 3. It reduces HC emission up to 80% **4.** It reduces PM emission 20 to 25%.	**2M** **Any 2 Point**
	d)	Compressor pressure ratio (CPR), is the ratio of the air total pressure exiting the compressor to	2M

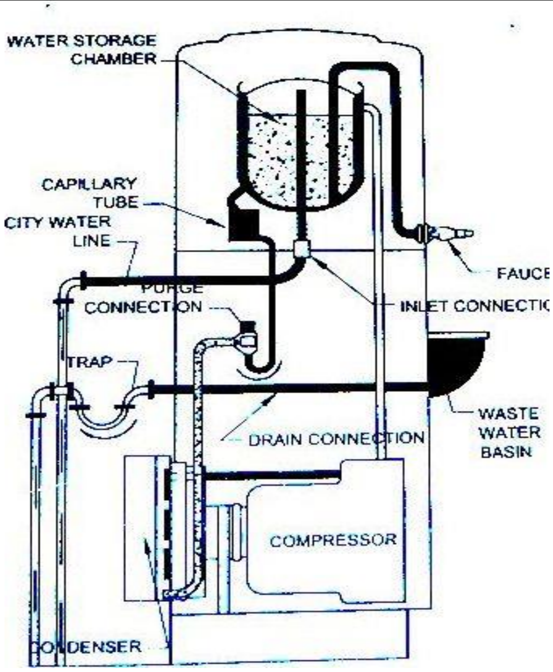
		the air pressure entering the compressor. This number is always greater than 1.0.	
	e)	Following are the components of jet engine: 1. Air intakes 2. Compressors 3. Combustors 4. Turbines 5. Afterburners (reheat) **6.** Nozzle 7. Bypass duct **8.** Shaft	Any Six For 2M
	f)	Following are the different liquid propellants used in rocket engines 1. kerosene, Liquid oxygen and Liquid Hydrogen similar to kerosene 2. Alcohol and its derivatives (Ethyl Alcohol) 3. hydrazine and its derivatives 4. Hydrogen peroxide 5. liquid hydrogen	2m ½ M Each Any 4 Point
	g)	Following are the objectives of supercharging 1. To compensate for loss of power due to high altitudes for air craft engines 2. To obtain better performance from the existing engine 3. For a given weight and bulk of the engine, super charging increase power output. This is important in air craft, marine and automotive engines where weight and space are considered 4. Super charging is done to induct more amount of air into cylinder per unit times and hence to burn more amount of fuel to increase power output	**2m** **½ M** **Each** **Any 2 Points**

Q.2	a)	 Actual Indicator diagram for 4 stroke petrol engine	4M
	b)	Graph indicating changes in pollutants level w.r.t air fuel ratio  	4M
	c)	Axial flow compressor : Working Principle: As the fluid enters and leaves in the axial direction, the centrifugal component in the energy equation does not come into play. Here the compression is fully based on diffusing action of the passages. The diffusing action in stator converts absolute kinetic head of the fluid into rise in pressure. The relative kinetic head in the energy equation is a term that exists only because of the rotation of the rotor. The rotor reduces the kinetic head of the fluid and adds it to the absolute kinetic head of the fluid i.e. the impact of the rotor on the fluid particles increases its velocity (absolute) and thereby reduces the relative velocity between the fluid and the rotor. In short increases the absolute velocity of the fluid and the stator converts this into pressure rise.	2M

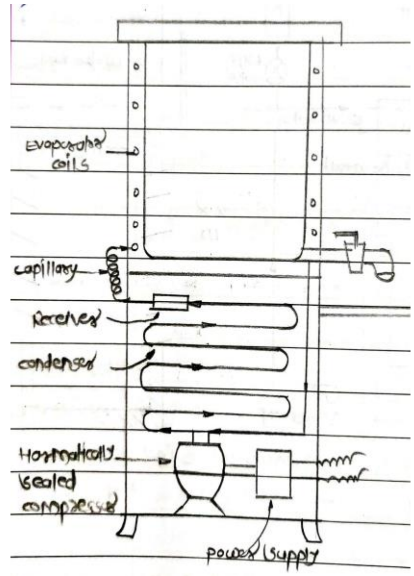
		 	2M
	d)	Heavy frame industrial gas turbines compared to aero derivative gas turbines are usually slower in speed, narrower in operating speed range, heavier, larger, have higher air flow, slower in start-up and need more time and spare parts for maintenance. Heavy frame industrial gas turbines use hydrodynamic bearing. Aero derivative gas turbines use anti-friction bearing. Advanced aircraft engine and space technologies have been used to provide maintainable, flexible, light weight and compact aero derivative gas turbines. The key to maintainability is the modular concept which provides for removal of components and replacement without removing the gas turbine from its support mounts. The heavy frame industrial units, by contrast, require more amount of effort to remove and replace components (especially combustor parts) and more effort to inspect or repair the sections. The user should weigh needs and requirements against the variety of gas turbines offered. Applications- Traditionally, preference has been to place the aero derivative units in remotely located applications (including offshore) and to place heavy frame industrial units in easily accessible base-load applications. The heavy frame industrial gas turbines consume more fuel and more air than the aero derivative units. They are exposed to a greater quantity of the contaminants in air that cause corrosion.	2M 2M
Q.3	a)	Following are Changes in automobile manufacturers in achieving BS6 norms of diesel engines 1. Reduction in HC emission by 45% 2. Reduction in NO_X emission by 70% 3. Reduction in PM emission by 80% 4. Use of Lean NO_X traps 5. Use selective catalytic reduction (SCR) 6. Use of Diesel particulate filter 7. Five times reduction in Sulpher %	**Any Four Changes 1M each**

		8. OBD for all diesel vehicles 9. Real Driving Emission introduced in vehicles 10. Fumigation 11. Catalytic converter monitoring 12. Misfire detection	
	b)	Combustion In S I Engine  According to Ricardo, There are three stages of combustion in SI Engine as shown in figure above 1. Ignition lag stage 2. Flame propagation stage 3. After burning stage 1. Ignition lag stage: There is a certain time interval between instant of spark and instant where there is a noticeable rise in pressure due to combustion. This time lag is called IGNITION LAG. 2. Flame propagation stage: Once the flame is formed at "b", it should be self sustained and must be able to propagate through the mixture. This is possible when the rate of heat generation by burning is greater than heat lost by flame to surrounding. After the point "b", the flame propagation is abnormally low at the beginning as heat lost is more than heat generated. 3.After burning: Combustion will not stop at point "c" but continue after attaining peak pressure and this combustion is known as after burning. This generally happens when the rich mixture is supplied to engine.	Fig. 2M Stages 2M

c)



OR



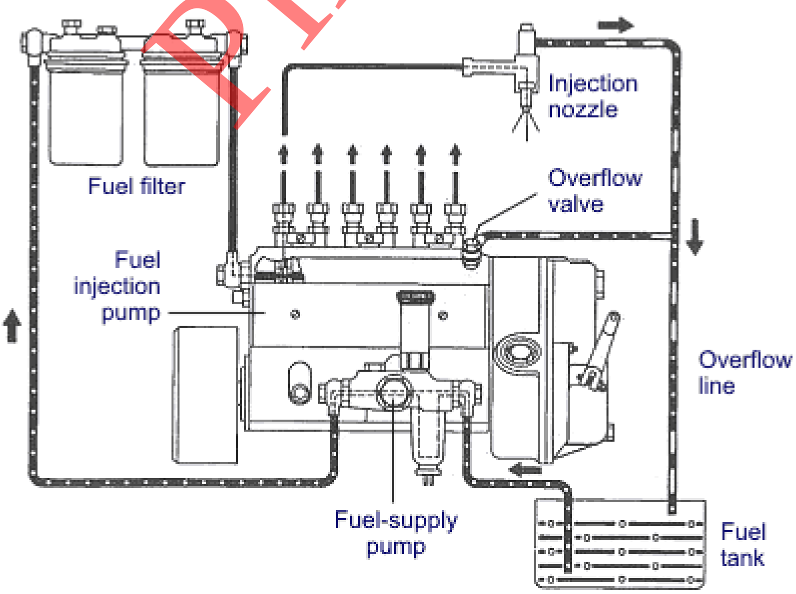
Storage type Water Cooler

Fig. 2M

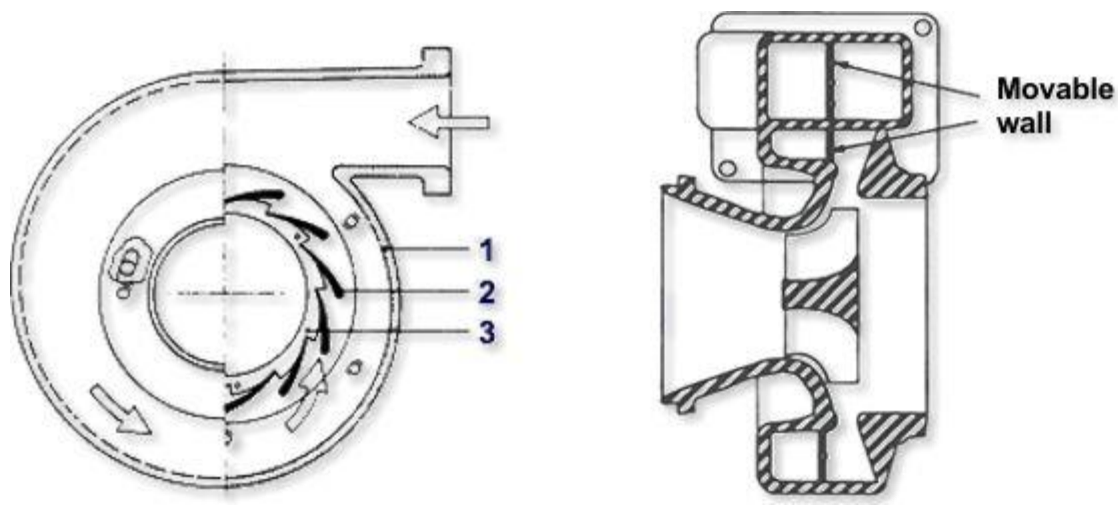
The storage type cooler has the evaporator coil soldered on to the walls of the storage tank of the cooler, generally on to the outside surface of the walls. The tank could be of the galvanized steel or stainless steel sheets. Water level is maintained in the tank by a float wall.

Push type water taps are generally provided for drawing cold water in both the types, to minimize the wastage of refrigerated water. Thermostat controls the operation of the compressor to maintain the water temperature at the desired level. The feeler bulb of the thermostat is clamped on to the water coil just at its outlet end in the instantaneous cooler. In the storage type, the bulb is kept immeresed in water in the tank or clamped to the wall of the storage tank on the outside at a lower level, much below the lower most evaporator refrigerant tube soildered on to the tank.

2M

	d)	Q3 (d) Compression ratio = 8 $\eta_{air\ std.} = 1 - \frac{1}{r_c^{\gamma-1}}$ $= 1 - \frac{1}{8^{1.4-1}}$ $= 0.5647$ $= 56.47\%$	2M
		No, the Otto cycle efficiency 56.47% will always be lower than Carnot cycle efficiency.	1M
		Justification: Carnot theorem states that keeping operating conditions same, Carnot engine is more efficient than any other engine. So, Otto cycle efficiency is lower than Carnot cycle efficiency.	1M
Q.4	a)	 **Inline Fuel Injection Pump**	Fig. 3M Naming 1M

b)



Sketch 2M

Variable Geometry Turbocharger

Variable Turbine Geometry technology is the next generation in turbocharger technology where the turbo uses variable vanes to control exhaust flow against the turbine blades. The problem with the fixed geometry turbocharger that big turbochargers do not work well at slow engine speeds, while small turbochargers are fast to spool but run out of steam pretty quick.

A turbocharger equipped with Variable Turbine Geometry has little movable vanes which can direct exhaust flow onto the turbine blades. The vane angles are adjusted via an actuator. The angles of the vanes vary throughout the engine RPM range to optimize turbine behaviour.

Justification 2M

c)

TEWI (Total equivalent warming impact) 2M

TEWI = $GWP \cdot L \cdot n + GWP \cdot m \cdot (1-\alpha) + n \cdot E \cdot \beta$ (1)

where, GWP - Refrigerant Global Warming Potential (equivalent to CO2) [kg CO2/kg refrigerant]

L - Annual leakage rate [kg/year]

n - System operating life time [years]

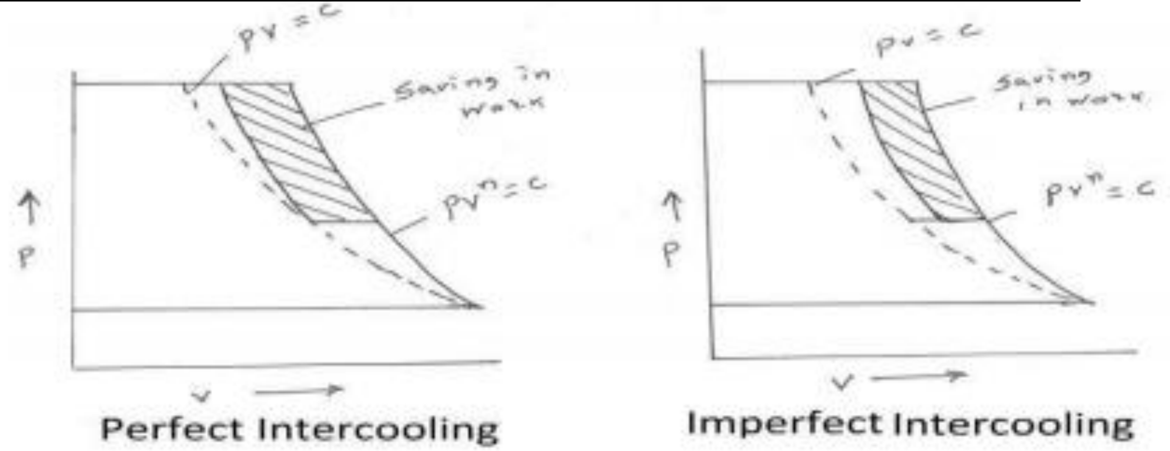
m - Refrigerant charge [kg] α - Recycling factor [%]

E - Annual energy consumption [kWh/year]

β - CO2 emissions on energy generation [kg CO2/kWh]

LCCP (Life-cycle climate performance) 2M

LCCP = TEWI + GWP (Indirect) [energy consumption expressed as CO_2- eq emissions from chemical production & transport, manufacturing components & vehicle assembly and end-of-life] + GWP (direct) [chemical refrigerant emissions including atmospheric reaction products, manufacturing leakage, and end-of- -life] d)



2 M each

e)

Turbojet Engine	Turboprop Engine
• Power produced by the turbine is used to drive the compressor	• Power produced by the turbine is used to drive the compressor and propeller.
• Low Takeoff thrust	• High Takeoff thrust
• Low Propulsive efficiency	• Propulsive efficiency is good.
• Less space is needed compared to turboprop engine.	• More space is needed
• Reduction gear is not needed	• Reduction gear needed
- Engine is noisy	- Engine is less noisy
- Engine consist of Diffuser, Compressor, Combustion Chamber, Turbine, Nozzle.	- Engine consist of Diffuser, Compressor, Combustion Chamber, Turbine, Nozzle with Propeller

Any four points 1M each

Q.5	a)	Q5 (a) Indicated Power = $P_m \cdot L \cdot A \cdot N$ $= 5.8 \times 10^5 \times 0.13 \times \frac{\pi}{4} \times (0.12)^2 \times \frac{940}{60}$ $= 13365.2$ W $= 13.365$ kW — (4)m Piston speed = $2LN$ $= 2 \times 0.13 \times \frac{940}{60}$ $= 4.073$ m/sec. — (2)m Speed in terms of m/min Piston speed = 244.38 m/min	

	b)	Q5 (b) $V_1 = V_s \times N$ $= \frac{\pi}{4} d^2 l \times N$ $= \frac{\pi}{4} \times (0.301)^2 \times 0.301 \times \frac{101}{60}$ $= \underline{0.0161\ m^3/sec.}$ — (2) M $P_1 V_1 = m R T_1$ $m = \frac{P_1 V_1}{R T_1} = \frac{1 \times 10^5 \times 0.0161}{287 \times 300}$ $= \underline{0.0187\ kg/sec.}$ — (2) M $W = \frac{n}{n-1} m R T_1 \left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right]$ $= \frac{1.25}{1.25-1} \times 0.0187 \times 287 \times 300 \left[\left(\frac{8}{1} \right)^{\frac{1.25-1}{1.25}} - 1 \right]$ $= 4151.69\ W$ $= \underline{4.152\ kW}$ — (2) M	

	c)	Q5 (c) $C.O.P. = \frac{h_1 - h_4}{h_2 - h_1}$ $= \frac{185-70}{206-185} = \underline{\underline{5.476}}$ — (2) M Ref. effect = 9.5 Tons $= 9.5 \times 210$ $= \underline{\underline{1995 \text{ KJ/min}}}$ Ref. effect $= m(h_1 - h_4)$ — (2) M $m = \frac{1995}{185-70}$ $= 17.35$ kg/min $= \underline{\underline{0.289 \text{ kg/sec.}}}$ — (2) M	

Q.6 a)

Q6 (a)

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

$$\text{Total } I.P. = I.P._1 + I.P._2 + I.P._3 + I.P._4$$

$$= 4.7 + 4.6 + 4.55 + 4.75$$

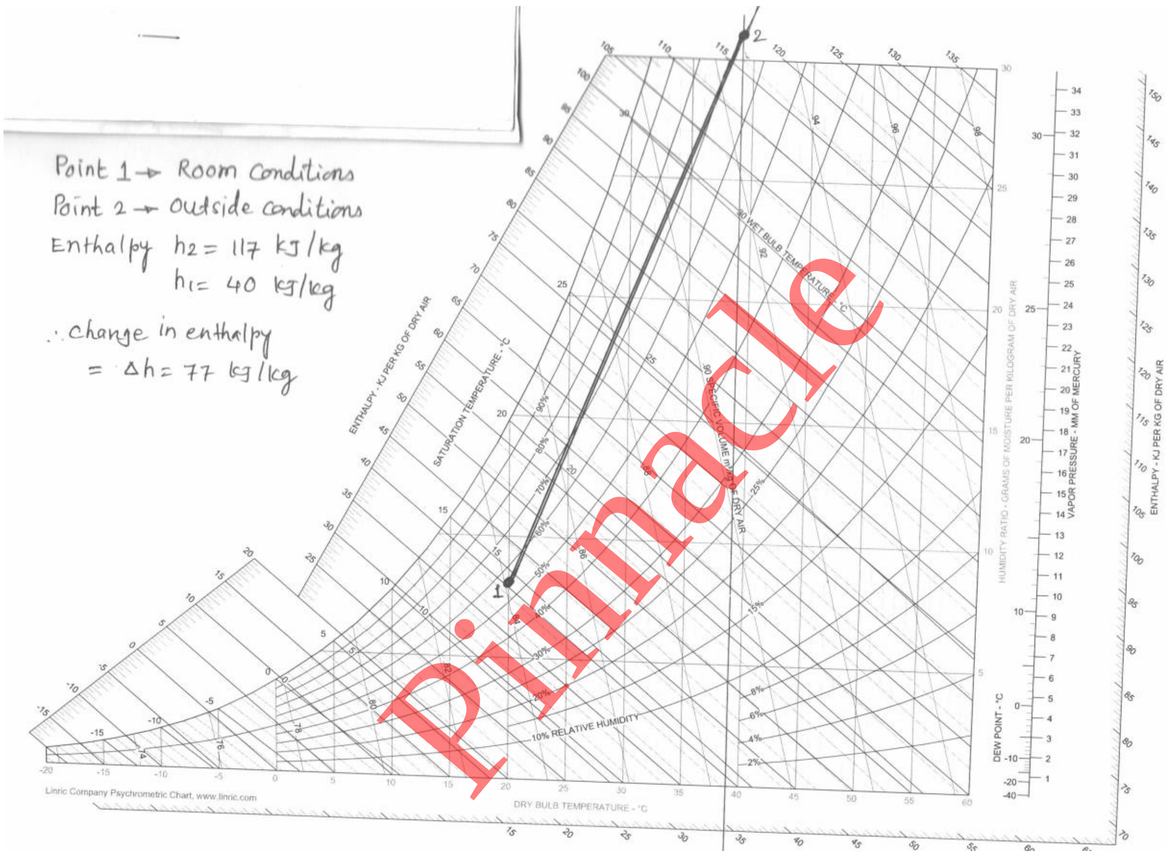
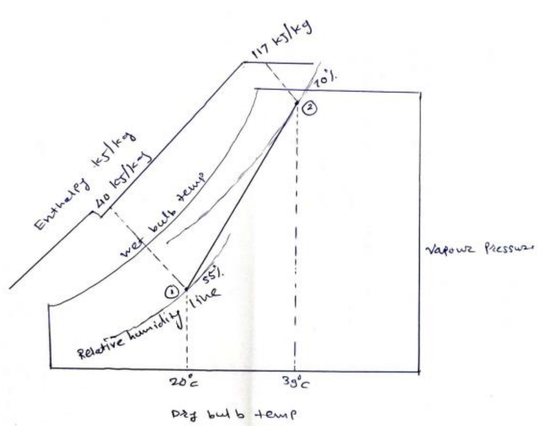
$$= 18.6\ kW$$ — (2) marks

$$\eta_{mech.} = \frac{B.P.}{I.P.} = \frac{16.25}{18.6} =$$

$$= 87.36\%$$ — (2) marks

b)

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.	Any Six points 1M each
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. 10. Receiver Compulsory 11. Mechanical Efficiency Low 12. More Starting torque required	9. It is used where large quantity of air at lower pressure is required. 10. Receiver not compulsory 11. Mechanical Efficiency High 12. Less Starting torque required	
	c)	 Skelton diagram - 		3 Marks for calculation 3 Marks for dig.