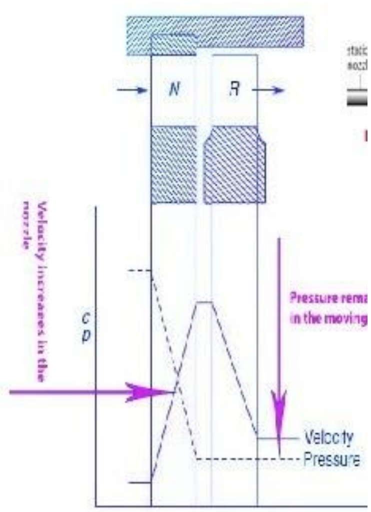
Important Instructions to examiners:

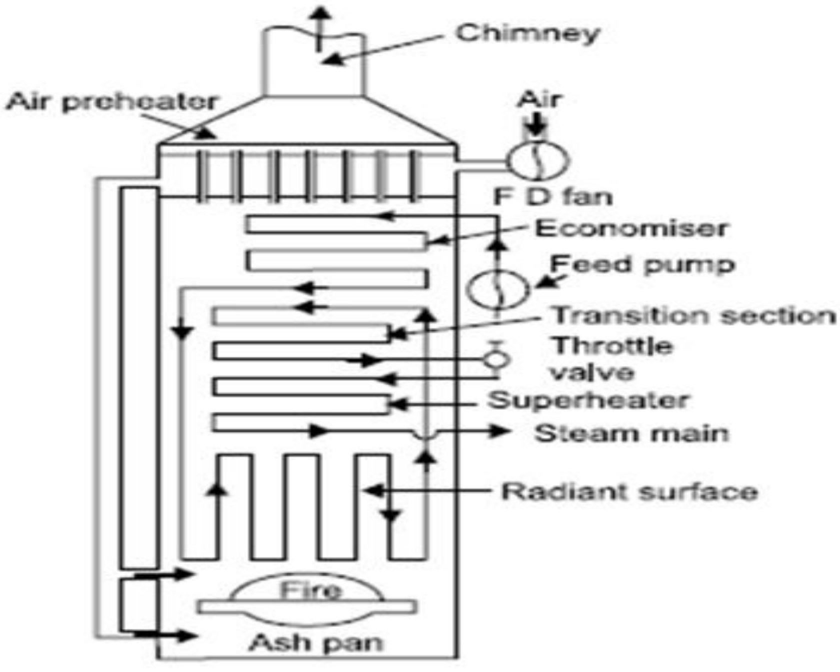
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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.	Answer	Marking Scheme
1	a)	A Critical steam generator is a type of boiler that operates below critical pressure, it operates at low efficiency and have more emissions A supercritical steam generator is a type of boiler that operates at supercritical pressure, frequently used in the production of electric power	2M
	b)	**Define the term boiler efficiency. State the types of boiler efficiencies.** Ans. ***Boiler efficiency*** is the fraction of energy input that actually goes into raising steam. Thus it could be given by the ratio of heat actually used for steam generation and total heat available due to combustion of fuel in boiler. $$\text{Boiler efficiency} = \frac{\text{Heat used in steam generation}}{\text{Total heat available due to fuel burning}} = \frac{m(h-h_w)}{m_f \times C.V.}$$ Where m_f is the mass of fuel burnt per hour, C.V. is calorific value of fuel used (kJ/kg), m is mass of steam generated per hour and enthalpies h and h_w are that of final steam and feed water, kJ/kg. Generally high heating value of fuel is used as calorific value of fuel. If the boiler, economizer and super heater are considered as a single unit, the boiler efficiency is termed as overall efficiency of the boiler. (otherwise considered differently)	2M

	c)	**i) Bottom Dead Centre (B.D.C.) –** The lowest position of the piston towards the crank end side of the cylinder is called bottom dead centre. ii) **Clearance Volume** – The volume contained in the cylinder above the top of the piston , when the piston is at TDC.	**1M each**
	d)	**Following are the applications of compressed air in industry - *(Any Four)* 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.	
	e)	**Function of impeller** - An impeller is a rotating component of a centrifugal pump which transfers energy from the motor that drives the pump to the fluid being pumped by accelerating the fluid outwards from the center of rotation. **Function of casing -** A volute is a curved funnel that increases in area as it approaches the discharge port. The volute of a centrifugal pump is the casing that receives the fluid being pumped by the impeller, maintaining the velocity of the fluid through to the diffuser.	**1 Mark each**
	f)	**Variation of pressure and velocity of steam in simple impulse turbine**  	**2 M**

	g)	**Following are the different power losses in steam turbine.** **(Any four points each for 1/2 mark)** 1) Residual velocity loss 2) Losses in regulating valves 3) Loss due to steam friction in nozzle. 4) Loss due to leakage 5) Loss due to mechanical frication 6) Loss due to wetness of steam 7) Radiation loss 8) Losses in exhaust piping	
	h)	**i) Compression ratio** – It is the ratio of. The absolute discharge pressure to the absolute inlet pressure. **ii) Swept Volume –** It is the volume swept through by the first stage piston in cubic metre per minute.	**1 M each**
	i)	**Application of pump (Any four) –** 1. Pumping water from wells, aquarium filtering, pond filtering and aeration 2. In the car industry for water-cooling and fuel injection 3. In the energy industry for pumping oil and natural gas 4. For operating cooling towers 5. Pumps are used for biochemical processes in developing and manufacturing medicine 6. artificial replacements for body parts, in particular the artificial heart *7. In hand soap dispenser* *8.* In car engine oil pumps and in various hydraulic power packs *9.* Car washes often use these triplex-style plunger pumps	**2M**
	j)	**Classification of I.C. engines on the basis of** **1) Method of ignition –** Spark ignition engine, Compression ignition engine **2) Thermodynamic cycle –** Otto cycle engine, diesel cycle engine, Dual cycle engine	**1 M each**
	k)	The basic difference between compressor and pump is A pump is a machine that moves a fluid either liquid or gas from one place to another. A compressor is a machine that compresses a gas into a smaller volume.	**2 M**
	l)	**Provisions under boiler act for remedial measures are (any 2 provisions, each for 1 mark)** No owner of a boiler shall use the boiler or permit it to be used 1. Unless it has been registered in accordance with the provision of this act	

		2. In the case of any boiler which has been transferred from one state to another, until the transfer has been reported in the prescribed manner 3. Unless certificate or provisional order authorizing the use of the boiler is for the time being in force under this act 4. At a pressure higher than the maximum pressure recorded in such certificate or provisional order 5. Where the State Government has made rules requiring that boilers shall be in charge of persons holding certificates of proficiency or competency unless the boiler is in charge of a person holding the certificate required by such rules.	
	m)	***Boiler efficiency*** is the fraction of energy input that actually goes into raising steam. Thus it could be given by the ratio of heat actually used for steam generation and total heat available due to combustion of fuel in boiler. **Seasonal efficiency** is how well the boiler uses fuel over the entire heating season. It is the ratio of the total seasonal heat output used by the facility to the total seasonal fuel input. The seasonal efficiency depends on the boiler's steady-state efficiency, standby losses, and cycling losses.	**2 M**
2	a)	**BENSON BOILER (sketch 02 marks, Explain-02 marks)** It is a water tube boiler capable of generating steam at supercritical pressure. Figure shows the schematic of Benson boiler. Mark Benson, 1992 conceived the idea of generating steam at supercritical pressure in which water flashes into vapour without any latent heat requirement. Above critical point the water transforms into steam in the absence of boiling and without any change in volume i.e. same density. Contrary to the bubble formation on tube surface impairing heat transfer in the normal pressure boilers, the supercritical steam generation does not have bubble formation and pulsations etc. due to it. Steam generation also occurs very quickly in these boilers. As the pressure and temperatures have to be more than critical point, so material of construction should be strong enough to withstand thermal stresses. Feed pump has to be of large	

		capacity as pressure inside is quite high, which also lowers the plant efficiency due to large negative work requirement. Benson boilers generally have steam generation pressure more than critical pressure and steaming rate of about 130–135 tons/hr. Thermal efficiency of these boilers is of the order of 90%.  *Benson boiler*	
	b)	**Classification of pumps -** **A) Centrifugal pumps** 1- Axial flow pump 2- Radial flow pump **B) Positive displacement pumps** 1- Rotary gear pump 2- Rotary vane pump 3- Rotary lobe pump 4- Rotary screw pump 5- Reciprocating pump	**4M**

c) **Faults and remedies for less efficiency of I C engine (Any 2 , each for 2 marks)**

1. The air intake might be clogged, so there is fuel but not enough air – clean/ replace air filter
2. The fuel system might be supplying too much or too little fuel to the mix, meaning that combustion does not occur properly – check fuel system
3. There might be an impurity in the fuel (like water in your tank) that prevents the fuel from burning – clean fuel tank
4. piston rings are worn (allowing the air/fuel mix to leak past the piston during compression) – replace piston rings
5. The intake or exhaust valves are not sealing properly, again allowing a leak during compression – check for leakage
6. If your sparkplug or the wire leading to it is worn out, the spark will be weak – replace it

d) **Any four Differences – (Each for 1 Mark)**

Single stage compressor.	Multi stage compressor.
Only one cylinder for the compressor process	More than one cylinder is connected in series
Used in low pressure application	Achieve a very high pressure ratio
The size of the cylinder is very large when compared to the cylinders in the multistage compressor	Individual cylinders are small when compared to single cylinder compression
The temperature of the fluid due to compression is very high. No intercooler	Temperature is low intercooling is more efficient than cooling with a cylinder wall surface. It also reduces thermal stress
The high temperature damages cylinder head and burns lubricating oil	Lower temperature facilitates effective lubrication
Volumetric efficiency is very low for given pressure ratio	Volumetric efficiency is very higg for given pressure ratio

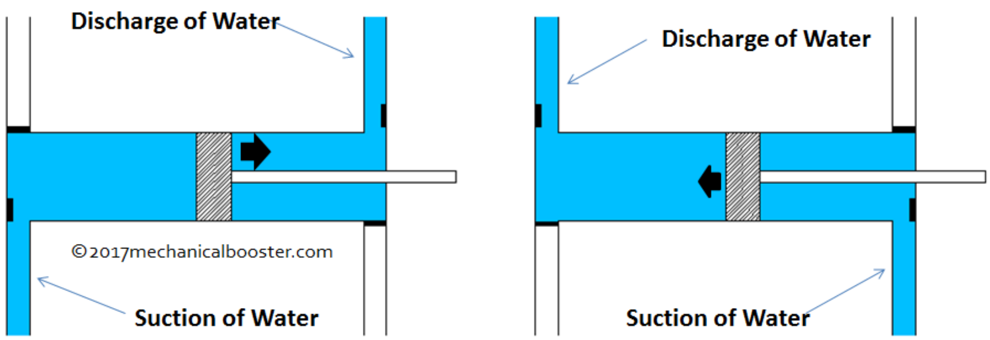
High leakage loss due to high pressure ratio	Chance of leakage loss is low
Suitable for light task	Suitable for heavy task. It can manage large load

e)

Working of Double Acting Reciprocating Pump

Sketch 2M

WORKING 2M



Double Acting Reciprocating Pump

As the piston moves to the right hand side as shown in the fig above. The following process takes place at left and right side.

At left side:

The suction valve opens and delivery valve gets closed. The water from the water reservoir is sucked into the cylinder.

At right side:

The suction valve is gets closed and delivery valve gets open. the water sucked in the previous stroke is discharges out of the cylinder.

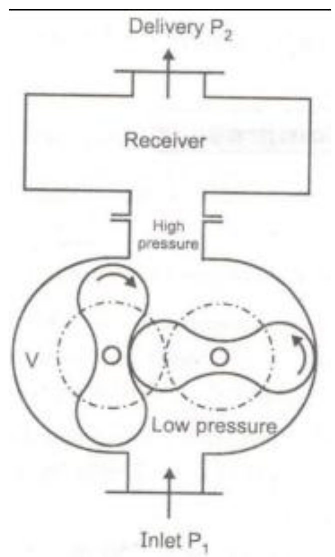
In the same way as the piston moves to left hand side, the discharge of the liquid takes place at left side and suction takes at the right side. And in each stroke of the piston, both suction and discharge of liquid takes place at the same time. If suction is taking place at right side than discharge takes place at left and vice-versa.

f

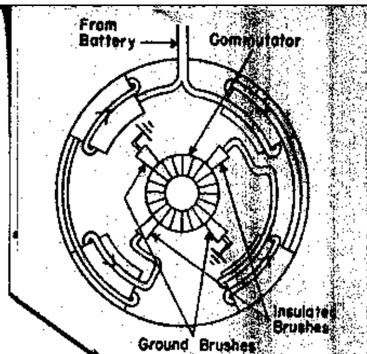
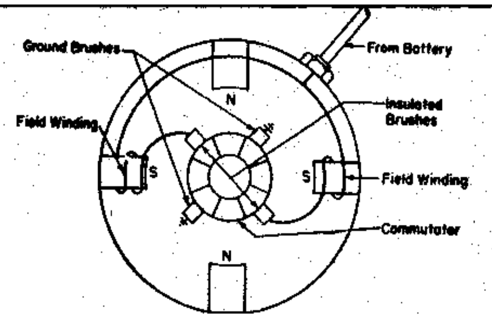
Any four difference each for 1 mark

Impulse turbine	Reaction turbine
1. Steam completely expands in nozzle and pressure remains constant during flow through the blade passage.	1. Steam expands partly in nozzle and further expansion take place in rotor

		2. Relative velocity of steam passing over blade of impulse turbine is constant. 3. Pressure is same at inlet and outlet. 4. Steam velocity is very high. 5. Lesser number of stages required. 6. It occupies less space per unit power. 7. Blades are symmetrical profile type.	blade passage. 2. Relative velocity increases as steam passing over the blade expands. 3. Pressure is different at inlet and outlet. 3. Steam velocity is not very high. 4. More numbers of stages required. 5. It occupies more space per unit power. 6. The blades are aerofoil & non symmetrical type.		
3	a	Fuel used to heat the fluid in the boiler is burned in a furnace portion of the boiler. In a boiler that employs water as the fluid contained therein, water walls are positioned around the furnace and contain tubes through which the fluid flows. The typically deaerated fluid is first fed to tubes of an economizer and then is fed to the tubes in the water walls. The economizer receives feed water and makeup water, which replaces losses from the steam produced. The economizer absorbs heat from flue gases produced from the burning of fuel in the furnace and transfers the heat to the feed water and the makeup water. In a supercritical boiler, fluid from the economizer is converted to steam as it passes through the tubes in the water walls. The steam may be used directly in a process (to produce work or as a source of heat). If not used directly in a process, the steam may be passed to a super heater wherein the steam is heated further. The superheated steam increases the efficiency of a steam turbine to which it is supplied.		**4 M**	

	b	**Lobe type air compressor**: it is a rotary type of compressor consisting of two rotors which are driven externally. One rotor is connected to drive and second is connected to gear. These two rotors have two or three lobes having epicycloids, hypocycloid or involutes profiles. In the figure two lobes compressor is shown with a inlet arrangement and receiver. A very small clearance is maintained between surfaces so that wear is prevented. Air leakage through this clearance decreases efficiency of this compressor. During rotation a volume of air V at atmospheric pressure is trapped between left hand rotor and casing. This air is positively displaced with change in volume until space is opened to high pressure region. At this instant some high pressure air rushes back from the receiver and mixed with the blower air until both pressure are equalized. 	**4M**
	c)	**Excessive noise in operation/ Compressor make noise**	**Any four causes – 1 m each**

Causes	**remedial action**
1. Loose pulley, flywheel, belt, belt guard, cooler, clamps or accessories.	Tighten any loose ends.
2. Lack of oil in crankcase.	Check for possible damage to bearings Replenish the oil level.
3. Piston hitting the valve plate.	Remove the compressor cylinder head and in foreign matter on top of the piston. Add a new gasket and reassemble the head.
4. Compressor floor mounting loose.	Tighten the bolts on the air compressor. It ma good idea to replace your vibration pads
5. Defective crankcase.	Repair or replace.

	d)	**Following three types of casings are commonly adopted** 1. Volute casing 2. Vortex casing 3. Casing with guide blades ***Description of any one casing – 3 Marks***	**1 M**
	e)	 Four-winding starting  [redacted] Two-winding starting motor.	**4 M**
	f)	**Procedure to conduct Morse test** First engine is allowed to run at constant speed and brake power of engine is measured when all four cylinder working. $(IP_1 + IP_2 + IP_3 + IP_4) = (BP)_{1234} + (FP)_{1234}$ ……………………………………………(1) Where, IP- indicated power. BP – brake power develop. FP – frictional power. I, 2, 3, 4 – cylinder number respectively. Now the first cylinder is cut off by short circuiting spark plug in case of S.I engine and by cutting fuel supply in case of C.I engine. Due to this, cylinder 1 will not develop IP_1 but continue to consume FP to measure BP $_{(234)}$.reduce speed to bring to initial speed by reducing load. $(IP_1 + IP_3 + IP_4) = (BP)_{234} + FP_{(1234)}$ ………………………………………………….. (2) When cylinder 2 is cut off and speed of engine returned to initial speed and to measure BP $_{(134)}$	**4 M**

$(IP_1 + IP_3 + IP_4) = (BP)_{134} + FP_{(1234)}$ ……………………………………………… (3)

When cylinder 3 is cut off and speed of engine returned to initial speed and to measure $BP_{(124)}$

$(IP_1 + IP_2 + IP_4) = (BP)_{124} + FP_{(1234)}$ ……………………………………………… (4)

When cylinder 4 is cut off and speed of engine returned to initial speed and to measure $BP_{(123)}$

$(IP_1 + IP_2 + IP_3) = (BP)_{123} + FP_{(1234)}$ ……………………………………………… (5)

Each cylinder of IP will get by,

i) Subtracting equation 2 from equation 1,

$IP_1 = BP_{(1234)} – BP_{(234)}$

ii) Subtracting equation 3 from equation 1,

$IP_2 = BP_{(1234)} – BP_{(134)}$

iii) Subtracting equation 4 from equation 1,

$IP_3 = BP_{(1234)} – BP_{(124)}$

iv) Subtracting equation 5 from equation 1,

$IP_4 = BP_{(1234)} – BP_{(123)}$

Thus indicated power of engine

$IP = IP_1 + IP_2 + IP_3 + IP_4$