Important Instructions to examiners:

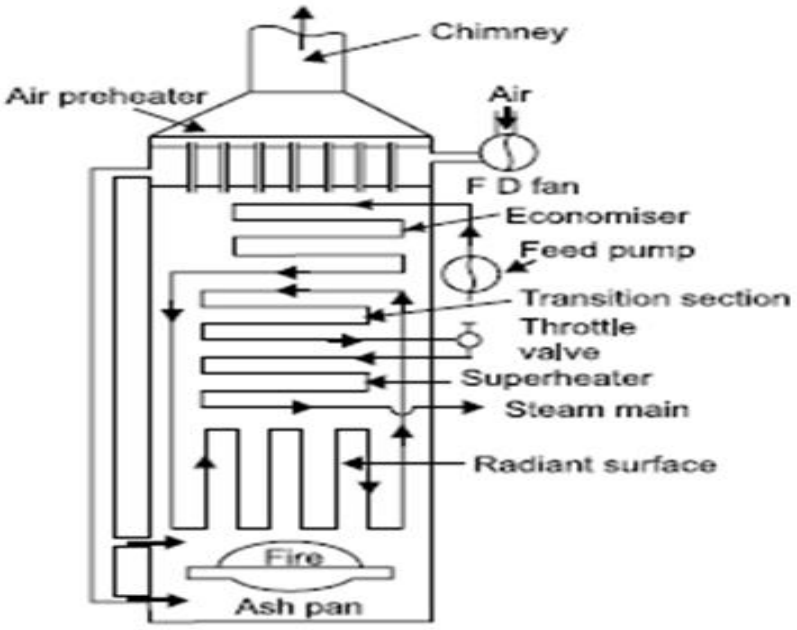
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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
1		**Attempt any Nine**	
	(a)	**Provisions under boiler act for remedial measures are** 1) Prohibitions of use of unregistered or Uncertified Boiler 2) Renewal of Certificate 3) Alteration and renewal to boilers 4) Alterations and renewals to steam - pipes	**Any 2 provisions, each for 1 mark)**
	(b)	Functions of steam boiler : 1. For generating steam for power in steam engines or steam turbines 2. In the textile industries for sizing and beaching and many other industries like sugar mills 3. For heating the buildings in cold weather and for producing hot water for hot water supply	**2 marks**
	(c)	***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.	**2 marks**

		$$\text{Boiler efficiency} = \frac{\text{Heat used in steam generation}}{\text{Total heat available due to fuel burning}}$$ $$= \frac{m(h - h_w)}{m_f \times \text{C.V.}}$$ 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.	
	(d)	**Following are the different power losses in steam turbine.** 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	**Any four each for ½ mark**
	(e)	**Frictional power**- loss of power due to friction in moving parts of I C Engine. It is the difference between I.P and B.P	**2 marks**
	(f)	The function of the starter motor is to start up the combustion engine. When the starter switch is turned on, the starter relay turns on the electric motor. This motor drives the starter gear ring via the pinion gear. The rotating movement of the starter motor is created through the interaction of two magnetic fields.	**2 marks**
	(g)	**The purpose of I.C. engine testing is** i) To reduce the cost and to improve the power output and reliability of an engine. ii) To know & improve the performance of an engine.	

	(h)	**Compressor capacity –** It is defined as the volume delivered by the compressor in cubic meter per minute.	
	(i)	Methods of Energy saving in air compressor 1. Cooling cylinder by spraying water during compression stroke. 2. Circulation of water surrounding to cylinder by providing jackets 3. Installing inter cooler between two cylinders 4. Providing greater fins on cylinder 5. By selecting suitable material for cylinder 6. By providing suitable choice of cylinder proportions i.e. short stroke and large bore in construction with sleeve valve	**Any two methods each for 1 mark**
	(j)	FAD (mean Free Air Delivery) (f.a.d) is the actual quantity of compressed air converted back to the inlet conditions of the compressor.	
	(k)	**Power required to drive the reciprocating pump** Power required to drive the pump = $(w \times ALN/60) \times (h_s + h_d)$	
2	**(a)**	**BENSON BOILER** 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	**sketch 02 marks,** **Explain- 02 marks**

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) Differentiate between fire tube boilers and water tube boilers **(Any four points , 1 mark each)**

Sr. No	Fire tube boilers	Water tube boilers
01	Hot flue gases flow in the tubes surrounded outside by the water	Water flows in the tubes surrounded outside hot gases
02	Slower in operation and have low evaporation rates	faster in operation and have low evaporation rates
03	Failure due to Temperature stress causing failure of feed water arrangement is minimum	Failure due to Temperature stress causing failure of feed water arrangement is more
04	It can work upto 20 bar pressure only	It can work upto 200 bar pressure
05	Simple and rigid construction	Complex construction
06	More maintenance and operation cost	less maintenance and operation cost
07	Smaller sizes and hence not suitable for large power houses	Bigger sizes and hence suitable for large power houses
08	Installation is difficult	Installation is easy
09	Requires less floor area	Requires more floor area

(c)

Q2 (c) Given,

$d = 100\ mm = 0.1\ m$

$l = 151\ mm = 0.151\ m$

$N = 300\ r.p.m.$

Indicated mean effective pressure (P_m) = $\frac{\text{Area of Indicator Diagram}}{\text{Length of indicator Diagram}} \times \text{spring constant}$

$= \frac{425}{63} \times 1.2$

$= 8.09\ bar$ (2 marks)

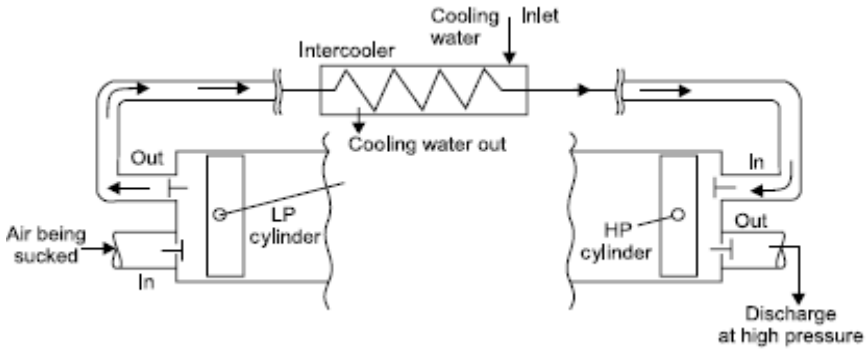
Indicated Power (I.P.) = $P_m L A \cdot \frac{N}{n}$; $n = 2$ for four stroke cycle

$= 8.09 \times 10^5 \times 0.151 \times \frac{\pi}{4} \times (0.1)^2 \times \frac{300}{2 \times 60}$

$= 2401.10\ W$

$= 2.40\ kW$ (2 marks)

(d)



Two stage reciprocating compressor

Fig. 2 Marks

Working 2 Marks

Multistage compression refers to the compression process completed in more than one stage i.e. a part of compression occurs in one cylinder (L.P. cylinder) and subsequently compressed air is sent to subsequent cylinders (H.P. cylinder) for further compression.

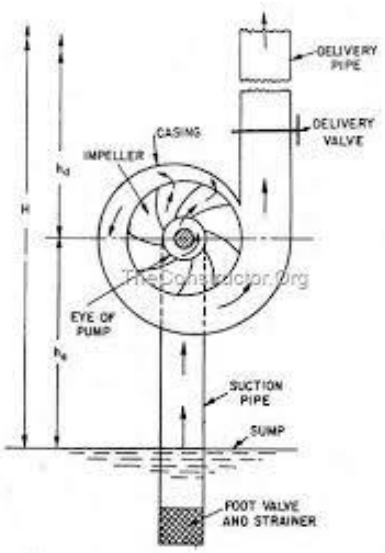
Figure shows the schematic of two stage compressor with intercooler between stages. The total work requirement for running this shall be algebraic summation of work required for low pressure (LP) and high pressure (HP) stages. The size of HP cylinder is smaller than LP cylinder as HP cylinder handles high pressure air having smaller specific volume.

(e)

Any four 01 mark each

Excessive noise in operation/ Compressor make noise

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 inspect for 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 may also be a good idea to replace your vibration pads	
5. Defective crankcase.	Repair or replace.	

		6. Excessive crank end play.	Adjust and shim properly.	
	(f)	**Centrifugal pump-**  A centrifugal pump is a pump in which an impeller rotating inside a close fitting casing draws in liquid at the centre and by virtue of centrifugal force, throws out through an opening or openings at the side of casing. In operation, the pump is filled with water and the impeller is rotated. The blades cause the liquid to rotate with the impeller and in turn, impact a high velocity to the water particles. The centrifugal force causes the water particles to be thrown from the impeller into casing. The forward flow through the impeller reduces pressure at the inlet, allowing more water to be drawn in through the suction pipe by atmospheric pressure or an external pressure. The liquid passes into the casing, where its high velocity is reduced and converted into pressure and the water is pumped out through the discharge pipe.	**Working – 2 marks, Sketch–2 marks**

3	(a)

Q. 3 a) For constant enthalpy process

$$h_{f1} + x_1 h_{fg1} = h_{f2} + x_2 h_{fg2}$$

suffix 1 represents 8 bar pressure
& 2 represents 1.2 bar pressure

Taking values from steam table,

At 8 bar,

$h_{f1} = 720.9$ KJ/kg $s_{f1} = 2.0457$ KJ/kg°K

$h_{fg1} = 2046.5$ KJ/kg $s_{fg1} = 4.6328$ KJ/kg°K

$x_1 = 0.8$

At 1.2 bar,

$h_{f2} = 439.4$ KJ/kg, $s_{f2} = 1.3609$ KJ/kg

$h_{fg2} = 2244.1$ KJ/kg, $s_{fg2} = 5.9375$ KJ/kg

$x_2 = ?$

putting values

$$720.9 + 0.8 \times 2046.5 = 439.4 + x_2 \times 2244.1$$

$$\therefore x_2 = 0.85$$

Quality of steam = dryness fraction

$= x_2 = 0.85$ (02 marks)

Change in entropy $= s_2 - s_1$

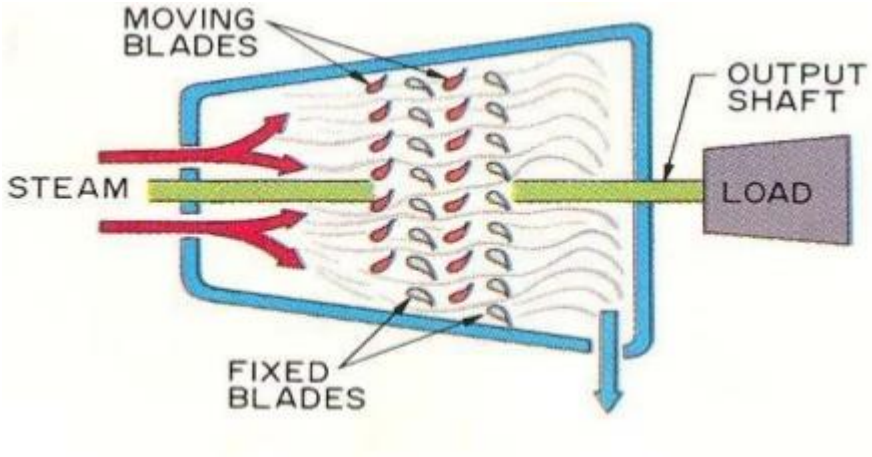
$= (s_{f2} + x_2 s_{fg2}) - (s_{f1} + x_1 s_{fg1})$

$= (1.3609 + 0.85 \times 5.9375) - (2.0457 + 0.8 \times 4.6328)$

$= 0.559$ KJ/kg (02 marks)

(b)

Reaction turbine principle :



In a reaction turbine the steam increases in speed as it passes through the moving blades. The fixed blades direct the steam to other moving blades.

(c) Engine do not start or gives starting trouble , troubles and remedies

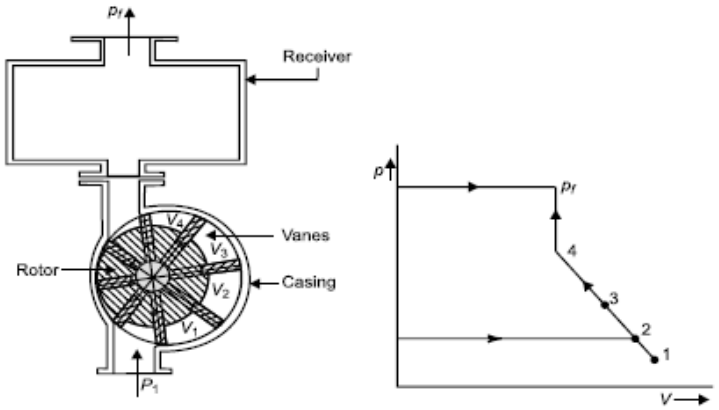
Any four 01 mark each

Battery is uncharged	Battery charge
Starting motor not working	Motor repair
Starter solenoid not working	Repair solenoid
Starter relay not working	Starter relay change
Loose wire connection	Check wire connection

(d) ***Vane type rotary compressor:*** Schematic of vane type compressor is shown in Fig.(a) It has cylindrical casing having an eccentrically mounted rotor inside it. The rotor has number of slots in it with rectangular vanes of spring loaded type mounted in slots. These vanes are generally non-metallic and made of fiber or carbon composites or any other wear resistant material. These vanes remain in continuous contact with casing such that leakage across the vane-casing interface is minimum or absent. It has one end as inlet end and other as the delivery end connected to receiver. Upon rotation the eccentric rotor has the vanes having differential projection out of rotor depending upon their position. Air is trapped between each set of two consecutive blades in front of inlet passage and is

Working – 2 marks, Sketch–2 marks

positively displaced to the delivery end after compressing the volume *V*1 initially to *V*2, *V*3 and *V*4. When compressed volume comes in front of delivery passage and further rotation results in the situation when partly compressed air is forced to enter the receiver as there is no other way out. This cumulative transfer of partly compressed air in receiver causes irreversible compression resulting in gradual pressure rise.



(a) Schematic of vane compressor (b) *p-V* diagram

Vane type compressor

(e) **Following are the different types of impellers** — **Types – 1 mark, application 1 mark each**

1. Fully closed type – It is suitable for handling clear and thin liquids.

2.Semi – closed type – It is suitable even if the liquids are charged with some debris.

3.Open type – Such impellers are useful in the pumping of liquids containing suspended solid matter, such as paper pulp, sewage and water containing sand or grit.

(f) Priming is the operation in which the suction pipe, casing of the pump and the portion of the delivery pipe up to the delivery valve is completely filled up from outside source with the liquid to be raised by the pump before the starting the pump.

This means that when there is no water in the pump, it is running in air. The pressure head developed is in terms of meters of air. Whereas when there is water, pressure head developed is in terms of meters of water. But as the density of air is very low, the generated head of air in terms of equivalent meter of water head is negligible and hence water may not be sucked from the sump. To avoid this difficulty, priming is necessary.