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. No.	Answer	Marking Scheme
Q. 1	(a)	i) Attempt any six Extensive property:- An extensive property of a system is one whose value depend upon the mass of the system. e.g. volume, energy, enthalpy, entropy, internal energy. ii) Zero Law of thermodynamics:- if state that "If two system are both in equilibrium with a third, are equilibrium with each other". If two bodies are separately in thermal equilibrium with a third body then they must be in thermal equilibrium with each other. iii) Charle's Law:- It state that "The volume of given mass of gas varies directly as its with the absolute temperature , when the absolute pressure remains constant $V \propto T or \frac{V}{T} = C$ iv) Universal gas constant – The product of molecular weight and specific gas constant of any gas is constant and is known as universal gas constant. $\bar{R} = M \times R$ M = Molecular weight of gas in kg R = Characteristic gas constant for same gas unit of universal gas constant J/kg-mole k v) Dryness fraction of steam:- The ratio of the mass of actual dry steam to the mass of wet steam containing it, is called the dryness fraction.	2 marks each

		$X = \frac{Ms}{Ms + mw}$ Ms = Mass of dry steam contain steam. Mw = Mass or water in suspension in steam. vi) Application of nozzle. 1) In flow measurement to measure discharge 2) Steam and gas turbine 3) Jet engines 4) Rocket motors 5) In flow measurement 6) In water sprinklers 7) In injectors for removing air from condensers. vii) Functions of steam condenser – 1) The exhaust steam from steam prime mover steam turbine or steam engines is condensed by taking away its heat while pressure is maintain below the atmosphere level heat energy released by stem in condensing is passed on to a coolant, which is water. 2) By using steam condenser hot & pure feed water can be supplied to boiler. viii)Dalton's Law of partial pressure- Total pressure exerted by the mixture is the sum of partial pressures, which each gas would exert if it separately occupied the whole volume and was at the same temperature as the mixture. P = Pa + Ps Where P = total pressure of mixture at temperature Pa = partial pressure exerted by air only at temperature Ps = partial pressure exerted by vapour only at temperature t t = common temperature in condense.	
	(b)	Any two i) Sources of air leakage in condenser i) Feed water to boiler contains contain some amount of dissolved air in it – This air goes in the condenser with exhaust steam. ii) The pressure inside the condenser is less than atmospheric so that the outside air leaks through joints, packing and gland into condensers.	4 marks each

iii) In jet condenser dissolved air with the cooling water enters the condenser and it gets separated at low pressure at low pressure in condensers.

Effect of air leakage in condenser-

1) If the air accumulates in the condenser it reduce vacuum i.e absolute pressure in condenser increase which means back pressure on perform mover increase as a result work done will be reduced.
2) Air being bad conductor effect the heat transfer action that the condensation becomes lower.
3) Increased flow of cooling water and large air pump require more power for deriving air pump and water pump.

ii) Define:-

Wet steam- Wet steam is defined as steam which is partly vapour and partly liquid water in it.

Dry saturated steam- The steam which do not contains any amount of water particle in it. is called dry saturated steam.

Super heated steam- When temperature of dry steam is greater than saturation temperature corresponding to given pressure vapour is said to be super heated steam.

Dryness fraction X

For wet steam x< 1

Dry saturated steam X = 1

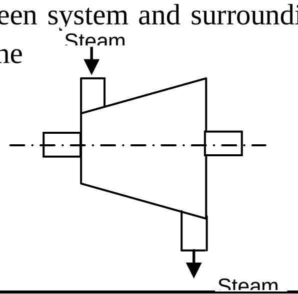
Superheated steam X > 1

ii) Fourier's Law of heat conduction – The law state that for homogeneous material the rate of heat transfer in steady state in any direction is linearly proportional to temperature gradient in that direction.

Stefan Boltzman Law- Stefan concluded from experimental data that' total radiation by block body par unit area per unit time is proportional to fourth power of absolute temperature of the body'.

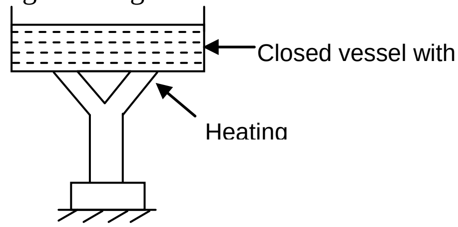
Q. 2 **(a)**

Open system :This is a system in which both mass and energy crosses the system boundary OR transfer of mass and energy between system and surrounding e.g. steam turbine



Closed system: In this system, there no mass transfer taking place between system and surrounding, only the energy crosses boundary

e.g. Heating of water in closed vessel



2 marks each

b.

Fire tube boiler	Water tube boiler
1. Hot gases are circulated through the tube and water flows over tube.	Water is circulated in tube and hot gases passed over the tube
2. Steam formation rate is low	Steam formation rate is high
3. It can produce steam up to 300^0c	If can produce steam up to 550^0c
4. Generate steam at lower pressure up to 25 bar	It can generate steam at higher pressure more than 25 bar
5. Operating cost low	Operating cost high
6. Overall efficiency with economiser is up to 75%	Overall efficiency with economiser is up to 90%
7. e.g. Locomotive boiler	e.g. Babcock & Wilcox boiler
8. Application locomotives	Application power plants
9. Various parts are not accessible for cleaning & inspection when boiler is working.	Various parts are accessible for inspection while boiler is working.

4 marks any four points

c.

Given data M = 1 kg, P_1 = 2 bar = 200 kPa, P_2 = 5 bar = 500 kPa

$T_1 = 302^0$ k, w = 0.712 kj/kg K

Taking relation $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $or\ V_1 = V_2$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$T_2 = \frac{P_2}{P_1} \times T_1 = \frac{500}{200} \times 302 = 755^0$ - Final temperature

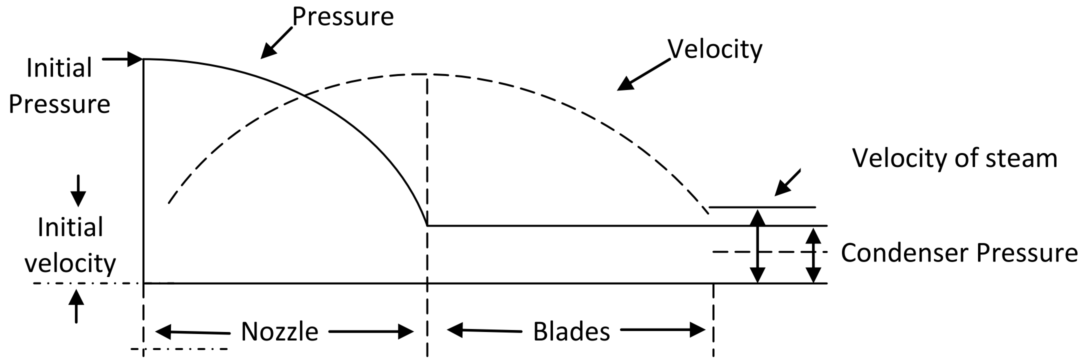
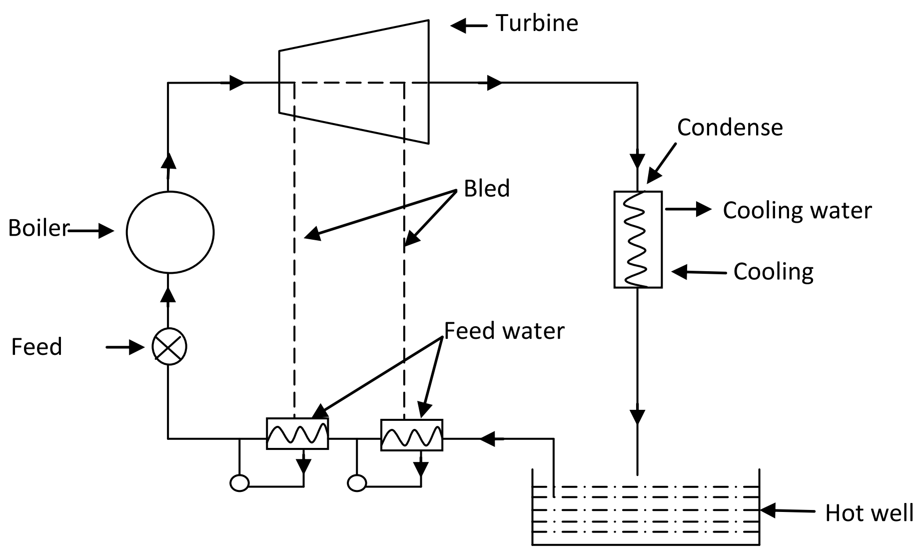
2 marks

Change in internal energy $(u_2 - u_1) = m \times cv(T_2 - T_1)$

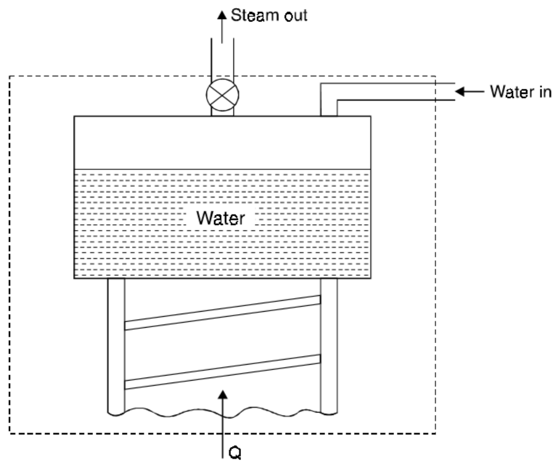
$$= 1 \times 0.712 \times (755 - 302)$$

$$\Delta u = 322.54kj$$

2 marks

	d.	Working of impulse steam turbine with pressure velocity variation diagram.  Impulse turbine consist of a set of nozzle and rings or moving blades. This blades are fitted on rim of rotating which is keyed to turbine shaft. This shaft is supported on bearing and whose assembly is enclosed in casting. High pressure steam from boiler expands to final (exhaust) pressure in sets of nozzle and gains a very high velocity. This kinetic energy of steam is converted into mechanical energy when steam passes over the rotor decode. The pressure remains constant in the moving blades. Pressure and velocity variation in nozzle and turbine and shown above.	2+2 marks
	e.	Regenerative feed heating  It is process of draining steam from turbine at certain point during its expansion and using these steam for heating the feed water supplied to boiler is known as bleed and the process of feed heating is known as regenerative feed heating.	2+2 marks
	f.	Given data Power input = 1.5 kw	

		Refrigeration effect = RE = 1 ton = 3.517 kw $T_2 = -20^0 c + 273 = 253^0 k$ $\therefore Cop(ref) = \frac{RE}{Power\ input} = \frac{3.517}{1.5} = 2.34$ $\therefore Cop(ref) = 2.34$ Again $Cop(ref) = \frac{T_2}{T_1 - T_2} = \frac{253}{(T_1 - 253)} = 2.34$ $\therefore (T_1 - 253) = \frac{253}{2.34} = 108.1$ $\therefore T_1 = 108.1 + 253$ $\therefore T_1 = 361.1\,K$	2 marks 2 marks
3.		Attempt any **FOUR** of the following	
	a) **Ans:**	**Write general steady flow energy equation and apply it to boiler and condenser.** Steady flow energy equation, [m (K.E. + P.E.+I.E.)$_1$+ m(PV)$_1$ + Heat transfer] Energy entering =[m (K.E. + P.E.+I.E.)$_2$ +m (PV)$_2$ + work transfer] Energy leaving $Z_1 g + V_1^2/2 + h_1 + q = Z_2 g + V_2^2/2 + h_2 + w$ **i) For Boiler**, $W = 0$, $V_1 = V_2$, $Z_1 = Z_2$ Therefore, $h_1 + q = h_2$ $q = h_2 - h_1$ h_1 = Enthalpy of feed water entering the boiler h_2 = Enthalpy of steam going out of the boiler	1 mark- steady flow energy equation, 1.5 marks – application to boiler, 1.5 marks – application to condenser



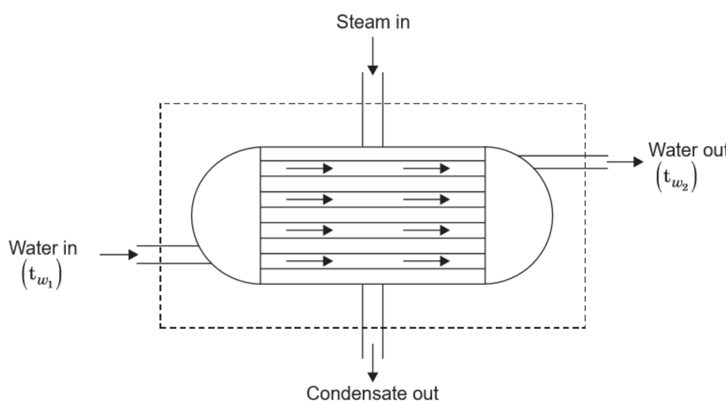
ii) For Condenser,

$W = 0$, $V_1 = V_2$, $Z_1 = Z_2$

$q = h_1 - h_2$

h_1 = Enthalpy of steam entering the condenser

h_2 = Enthalpy of condensate going out of the condenser



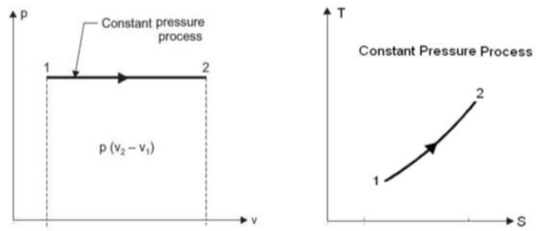
b) **Represent following ideal gas process on P-V and T-S diagram:**

1/2 mark for P-V diagramand 1/2 mark for T-S diagram

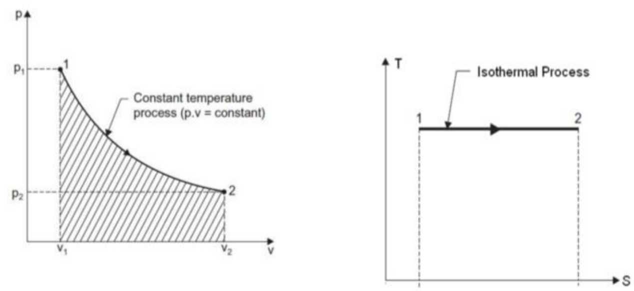
- **i) Isobaric process**
- **ii) Isothermal process**
- **iii) Adiabatic process**
- **iv) Polytropic process**

Ans:

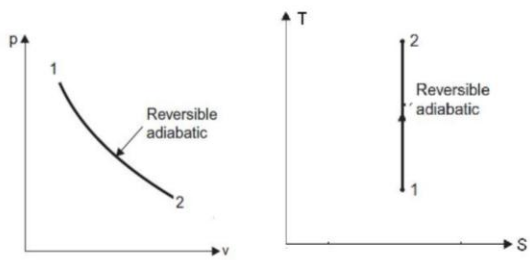
i) Isobaric process



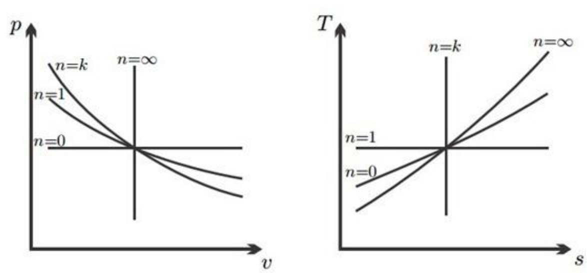
ii) Isothermal process



iii) Adiabatic process



iv) Polytropic process



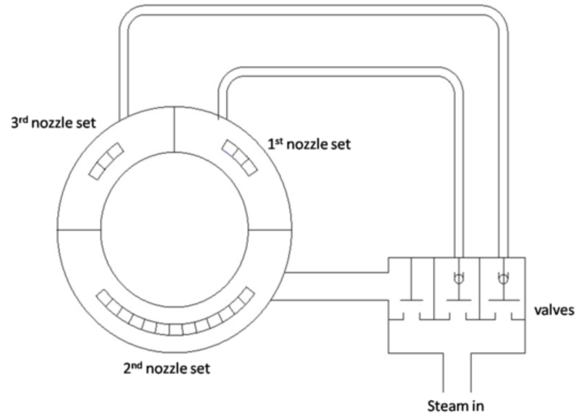
c) **Calculate the enthalpy of 1 Kg of steam at a pressure of 7 bar and dryness fraction 0.8. How much heat would be required to generate 2 kg of this steam from water at 30^{0}C.**

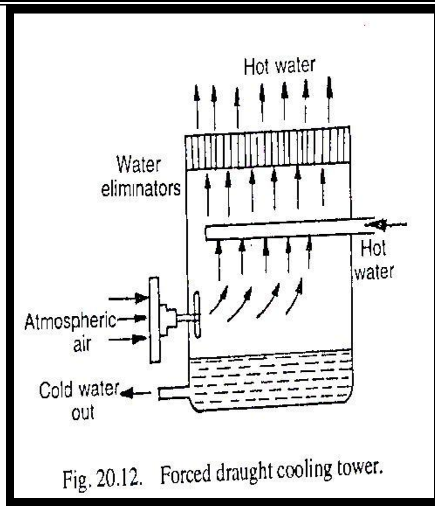
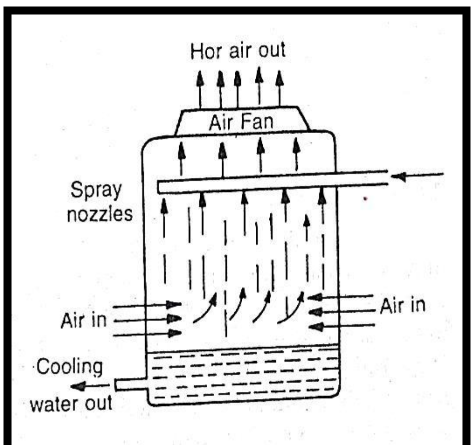
Take C_{pw} = 4.187 KJ/Kg^{0}K.

i) Enthalpy of 1 Kg of steam

From steam table

	Ans:	h_f= 697.20 KJ/Kg h_{fg} = 2066.3 KJ/Kg h_{wet}= h_f+x. h_{fg} h_{wet}= 697.20+0.8 X 2066.3 h_{wet}=2350.24 KJ/Kg ii) **heat required to generate 2 kg of steam** **a) Heat content by water at 30^{0}C.** h_{water}= m.C_{pw}. ΔT h_{water}= 2 X 4.187 X 30 h_{water}= 251.22 KJ/Kg **heat required to generate 2 kg of steam** h = h_{wet}- h_{water} h = 2350.24 - 251.22 h = 2099.02 KJ **Heat required to generate 2 kg of steam is equal to 2099.02 KJ**	2 marks-Enthalpy 2 marks-heat required
	d) **Ans:**	**Explain nozzle control governing of steam turbine.** In nozzle governing the flow rate of steam is regulated by opening and shutting of sets of nozzles rather than regulating its pressure. In this method groups of two, three or more nozzles form a set and each set is controlled by a separate valve. The actuation of individual valve closes the corresponding set of nozzle thereby controlling the flow rate. In actual turbine, nozzle governing is applied only to the first stage whereas the subsequent stages remain unaffected.Since no regulation to the pressure is applied. Figure shows the mechanism of nozzle governing applied to steam turbines. As shown in the figure the three sets of nozzles are controlled by means of three separate valves.	2 marks-Construction

			2 marks- Working
	e) Ans:	**What is function of cooling tower in steam power plant? List various types of cooling towers and sketch any one.** **Function of cooling tower:** Recycling of water through condenser is needed if cooling water supply is limited. Works same as evaporative condenser. Some % of water (1%) goes in form of water vapors taking its latent heat from remaining water. Causes reduction in temp.Of water coming out from condenser. **Types of Cooling tower:** **A) Acco. to type of draught** 1. Natural draught cooling towers. 2. Induced draught cooling towers. 3. Forced draught cooling towers **B) Acco. to materials used** **1. Timber cooling towers** **2. Concrete (ferro-concrete, multideck concrete hyperbolic) towers** **3. Steel duct type cooling tower** **Explanation of construction and working:** **i) Forced draft cooling tower:** forced draft cooling tower consist of spray nozzles, circulating pipelines, water tank, nozzles fan, pump and valves. Basically water is sprayed from topside by using spray nozzle. Air is taken inside by using fan. They flow in opposite direction. Fan is provided at bottom of tower as shown in figure. Make up water is supplied as and when required.	1mark – function, 1 mark- types,

		 Fig. 20.12. Forced draught cooling tower. **ii) Induced draft cooling tower:** It consist of fan motor, eliminators, spray nozzles and water tank. Fan is fixed at the topmost side as shown in figure. Air is induced from the inner space in which hot water is sprayed from the top. The mixing of water- air generates normal water, which is collected at bottom in water tank. Water can be recirculate by using pump. Make up water is added if needed.  20.13. Induced draught cooling tower. **iii) Natural draft cooling tower:** In natural draft cooling tower, hot water is pumped to ring trough's. Trough sprays water in the form of droplets, which is placed at bottom of towers. Most advantage is of no use of fan, for air circulation. An air circulation takes place by the pressure difference of air inside and outside of cooling tower (natural flow).	1 mark-any one explanation , 1 mark- Diagram

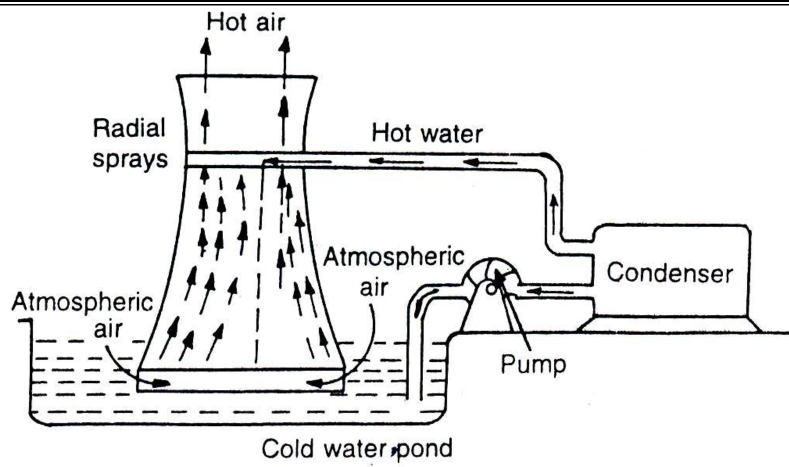


Fig. 20.11. Natural draught cooling tower.

	f)	**Write various modes of heat transfer. Give one example of each mode.**	
	Ans:	Heat is energy, which flow from one region to another due to temperature differences. **Heat transfer** is defined as the transmission of energy from one region to another as a result of temperature difference. Modes of heat transfer 1. Conduction, 2. Convection, 3. Radiation 1. **Conduction** – It is transmission of heat energy between two bodies or two parts of same body through molecules which are more or less stationery e.g. heating of solid- fins provided on engine, motor 2. **Convection** – It is process of heat transfer from higher temperature to lower temperature due to movement of matter or fluid molecules (density differences) is called convection. e.g. heating of water. **3.** **Radiation** – It is process of heat transfer between two bodies without any carrying medium through different kind of electro-magnetic wave. e.g. heating of earth surface by sun	1 mark-each definition
4		**Attempt any FOUR of the following.**	
	a)	**Give various statements of 1st law of thermodynamics.**	
	Ans:	First Law of Thermodynamics: - i) It states that if a system executes a cycle, transferring work and heat through its boundary, the net heat transfer is equivalent to the network transfer and does not place any restriction on the direction of flow but the reversal of the process not violet the first law. ii) According to this statement of first law the potential energy can be converted into kinetic	1 mark-each statement

energy and kinetic energy can be converted into potential energy but in natural practice this does not happen.

iii) Hence from above example the reversal of process is not true without the aid of external work.

iv) The principle of conservation of energy leads to first law of thermodynamics. This principle states that 'energy can neither be created nor be destroyed though it can be transformed from one form to another form of energy. According to this law, when a system undergoes a change of state (thermodynamic process) both heat and work transfer takes place. The net energy transfer is stored within the system and is known as stored energy or total energy of system.

$Q = \Delta U + W$

b) **List four boiler mountings and accessories giving function of each.**

Ans:

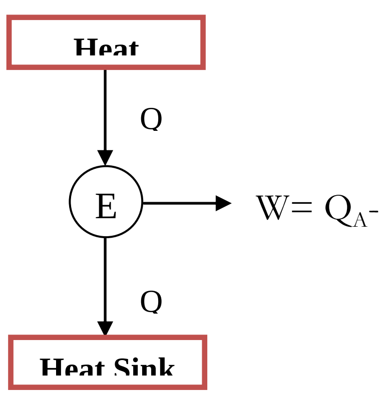
Boiler accessories:	**Function**
i) Air Preheater	Increases temperature of surrounding air by using hot waste flue gases which can be used in boiler furnace to increase boiler efficiency
ii) Economizer	Increases temperature of water by using hot waste flue gases which can be used in boiler drum to increase boiler efficiency
iii) Super heater	It is used to increase the temperature of dry saturated steam and convert it into superheated steam
iv) Water feed pump	To increase pressure of inlet water supply to boiler
v) Steam injector	To inject steam at high pressure in steam turbine
Boiler mountings:	**Function**
1) Feed check valve	To allow water flow into boiler
2) water level indicator	To check water level in boiler drum
3) Blow off cock	To pass water away from boiler for maintenance purpose
4) Pressure Gauge	To measure steam pressure generated in boiler drum
5) Steam Stop Valve	To control flow of steam to turbine
6) Safety Valve	To relieve excess steam from boiler drum generated at high pressure
7) Fusible Plug	To extinguish fire in furnace by allowing spray of water by melting molten material

02 Mark for any two mountings and accessories with use

	c)	**Give classification of steam turbine.**	
	Ans:	Classification of steam turbines: a) With respect to action of steam: i. Impulse turbine ii. Reaction Turbine b) With respect to method of compounding i) Pressure compounding ii) Velocity compounding iii) Pressure-Velocity Compounding c) With respect to expansion stages i) Single stage ii) Multistage d) With respect to direction of flow i) Axial flow ii) Radial flow iii) Tangential flow e) With respect to pressure of steam i) Low pressure ii) High pressure iii) Medium pressure f) With respect to shaft position i) Vertical shaft ii) Horizontal shaft g)According to The Nature Of Exhaust Steam. i) Condensing Type Steam Turbine. ii) Non Condensing Type Steam Turbine.	4 marks- any 6 types

		h) **According to No. Of Passes Of Steam Over Turbine Blades.** i) Single Flow Turbine. ii) Double Flow Turbine. i)**According to method of the governing.** i) Turbine. ii) Turning With Nozzle Governing. With Throttle Governing iii)Turbine With By Pass Governing. **j) According to their usage in industry.** i) Stationary Turbine With Constant Rotation Speed ii) Stationary Turbine With Variable Speed iii) Non Stationary Turbine With Variation Speed.	
	d) **Ans:**	**Define 'A perfect black body' by considering a body. Explain the terms-absorptivity, transmissivity and reflectivity.** **A perfect black body:** Black body absorbs the maximum incident energy as well as emits maximum energy at same temperature Heat radiation of all real bodies is compared with radiation of black body. Perfect black body doesn't exist. $Q_i = Q_a + Q_r + Q_t$ Dividing the above equation by Q_i $\frac{Q_a}{Q_i} + \frac{Q_r}{Q_i} + \frac{Q_t}{Q_i} = 1$ or $\alpha + r + \tau = 1$ i) **Absorptivity:**The fraction of radiation absorbed to incident radiation by the surface is called the absorptivity α $\alpha = \frac{Absorbed\ radiation}{Incident\ radiation} = \frac{Qa}{Qi}$ ii) **Reflectivity:**The fraction of radiation reflected to incident radiation by the surface is called the reflectivity γ $\gamma = \frac{Reflected\ radiation}{Incident\ radiation} = \frac{Qr}{Qi}$	1 mark - each definition

		iii) **Transmissivity:** The fraction of radiation transmitted to incident radiation is called the transmissivity τ $\tau = \frac{Transmitted\ radiation}{Incident\ radiation} = \frac{Qt}{Qi}$	
	e) Ans:	**Define vacuum efficiency and condenser efficiency.** **Condenser efficiency**: it is defined as the ratio of difference between the outlet and inlet temperature of cooling water to the difference between saturation temperature corresponding to condenser pressure and inlet temperature of cooling water **Condenser efficiency** $= \frac{(Two - Twi)}{(Ts - Twi)}$ **Condenser efficiency**= Actual rise in cooling water temperature/ Maximum rise in cooling water temperature Max rise = (saturation temperature corresponding to condenser pressure) – (inlet temp.) **Vacuum efficiency**: It is defined as the ratio of actual vacuum to the ideal vacuum. Ideal vacuum = (Atmospheric pressure) **-**(Saturation pressure corresponding to condensation temp) • Ps=Psat of steam corr. to temp of water entering in condenser • Pt= total pr of air & steam in condenser (Pa+Ps) • Pb= atmpr or barometric pr • Ideal vacuum possible without air leakage=(Pb-Ps) • Actual vacuum present in condenser due to air leakage=(Pb-Pt) =Pb-(Pa+Ps) **Vacuum efficiency** $= \frac{([Pb - (Pa + Ps)])}{(Pb - Ps)}$	1 Mark for definition and 1 mark for formula for both
	f) Ans:	**Wet steam at 10 bar pressure having total volume of 0.125 m^3 and enthalpy content is 1800KJ. Calculate mass and dryness fraction of steam.** **Given:** P = 10 bar, V = 0.125 m^3, h_{wet}= 1800KJ, **To find, m and x** **From steam table** h_f= 762.79 KJ/Kg	

		h_{fg} = 2015.3 KJ/Kg **i) to find mass of steam** P.V = m.R.T m = P.V / R.T m = (10 X 10^5 X 0.125)/(283 X (179.91+273)) **m = 0.9752 Kg** **ii) to find dryness fraction of steam** **Enthalpy of wet steam** h_{wet}= m.(h_f+ x. h_{fg}) 1800= 0.9752 (762.79 + x X 2015.3) **x = 0.5373** **The mass of steam is 0.9752 Kg and dryness fraction is 0.5373.**	2 marks-mass 2 marks-dryness fraction
Q. 5.		**Attempt any TWO of the following:**	**16**
a)	**(i)**	**State Kelvin-Plank statement and Clausius statement of second law.**	**04 Marks**
Sol.		**Kelvin-Plank Statement:** According to Kelvin-Plank's, "It is impossible to construct an engine working on cyclic process, whose sole purpose is to convert heat energy from a single thermal reservoir into an equivalent amount of work."  **Where,** W= Work done Q_A=Heat Absorbed Q_R=Heat Rejected **Fig. Heat**	**02 Marks**

Clausius Statement:

According to Clausius, "It is impossible to construct an engine working in a cyclic process, whose sole purpose is to transfer the from low temperature reservoir to high temperature reservoir without aid an external source."

02 Marks

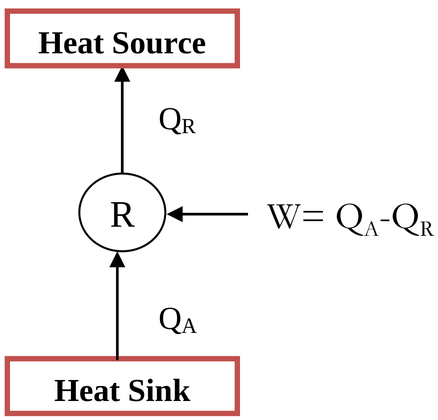


Fig.Refrigerator

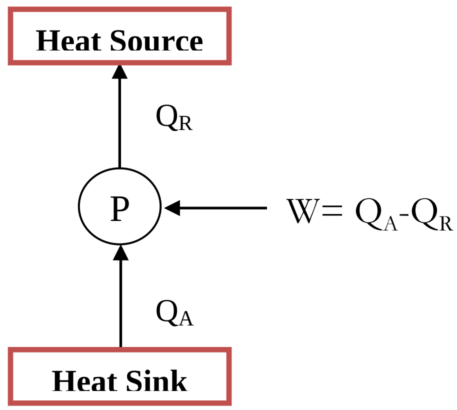


Fig.Heat Pump

(ii) Prove that the Kelvin-Plank and Clausius statement are equivalent. **04 Marks**

Sol.

Kelvin-Plank and Clausius statement seems for second law of thermodynamics seems to be different, but they are equivalent to each other. It can be proved, if it is shown that, violation of one statement means the violation of other and vice versa.

Violation of Kelvin-Plank statement:

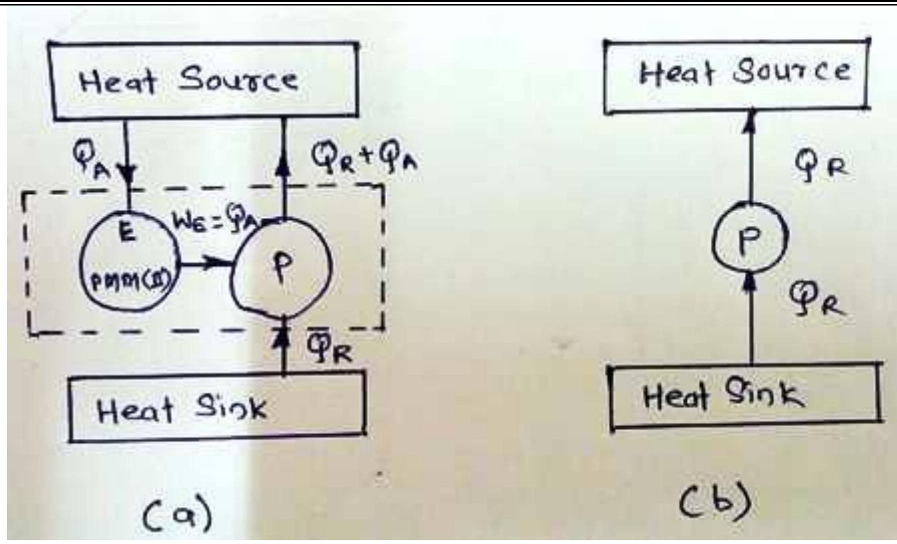
Consider a heat engine having 100% efficiency(PMM-II) i.e. violating Kelvin-Plank statement. Such a heat engine will convert the heat the heat energy supplied Q_A into equivalent amount of work(W_E).

02 Marks

$$Q_A=W_E$$

This work produced can be utilized to drive a heat pump, which receives amount of heat $Q_A$from cold body (Heat sink) and rejects an amount of heat ($Q_A + Q_R$) to hot body , as shown in fig.(a).

If the combination of heat engine and heat pump is considered as single system, the result will be a device (heat pump), which delivers heat Q_A from cold body to hot body wthout having any external work done, this this violating Clausius statement. As shown in fig.(b).



Violation of Clausius statement:

Consider a heat pump (PMM-II), which violates the clausius statement, as it transfers the heat from a low temperature reservoir (Cold body) to high temperature reservoir (hot body) without external work. Let $\mathbf{Q_A}$ be the heat transferred from cold body to hot body by heat pump without aid of external work.

Now let a heat engine absorbs an amount $\mathbf{Q_A}$ and produce work,

02 Marks

$$W_E = Q_A - Q_R$$

Where, W_E= Work done, Q_A=Heat Absorbed, Q_R=Heat Rejected

as shown in fig.(C).

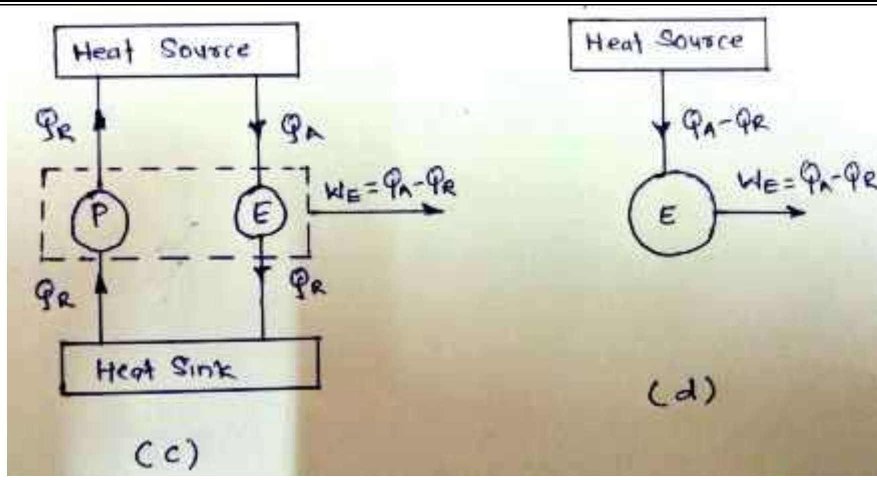
If the combination of heat pump and heat engine is considered as single system, then result will be a device(heat engine), whose aim is to deliver the work,

$$W_E = Q_A - Q_R$$

It means that, the total amount of heat received ($Q_A - Q_R$) from heat source is converted completely into work done WE= $Q_A - Q_R$. as shown in fig.(d).

This heat engine violates Kelvin-Plank statement.

Hence violation of Clausius statement leads to violation of Kelvin-Plank statement.



b)		**Why compounding of steam turbine is necessary. State methods of compounding and describe any one in brief.**	**08 Marks**

Sol.

Necessity of Compounding of steam turbine:

Compounding of steam turbines is done: **04 Marks**

- ✓ To reduce speed of rotor blades to practical limits.
- ✓ To reduce centrifugal force and hence to prevent failure of blades.
- ✓ To reduce velocity of steam leaving blades.

Methods of Compounding:

- ✓ Pressure compounding
- ✓ Velocity compounding
- ✓ Pressure and Velocity Compounding

i) Pressure Compounding:

- ✓ In pressure compounding arrangement of blades and nozzles are made as below;

N-M-N-M-N-M

Where;

N= Nozzle

M= Moving blade

04 Marks for Any one type of compounding.

- ✓ Nozzle is reduced the pressure and increase the velocity.
- ✓ Moving blade absorb the kinetic energy of steam.
- ✓ Figure shows the rings of fixed nozzles incorporated between the rings of moving blades. The steam at boiler pressure enters the first set of nozzles and expands partially. The kinetic energy of the steam thus obtain is absorbed by the moving blades (stage 1). The steam then expands partially in second set of nozzles where its pressure again falls and the velocity increases; the kinetic energy so obtained is absorbed by the second ring of moving blades(stage 2). This is repeated in stage 3 and steam finally leaves the turbine at low velocity and pressure. The number of stages depends on the number of

rows of nozzles through which the steam must pass. The changes in pressure and velocity are shown in figure.

OR

ii) Velocity Compounding:

- ✓ Steam expanded through nozzle from boiler to condenser pressure.
- ✓ K.E. increases of the steam increases due to increasing velocity.
- ✓ Fixed blades redirect the steam flow without altering its velocity.
- ✓ The changes in pressure and velocity are shown in figure.
- ✓ This method has advantage that the initial cost is low so its efficiency is low.
- ✓

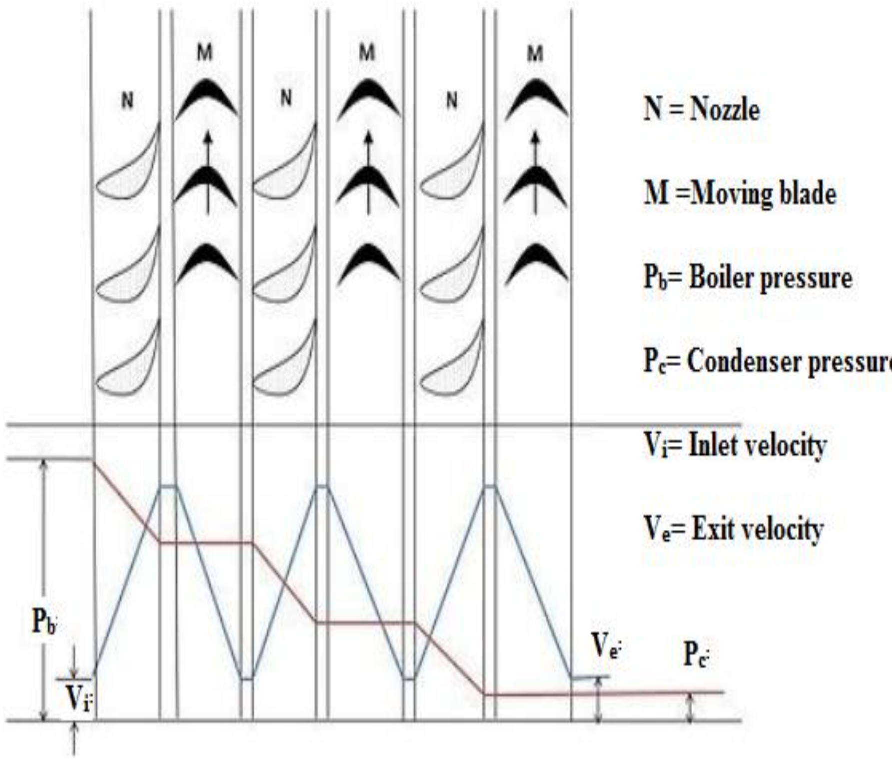


Figure:
Pressure compounding

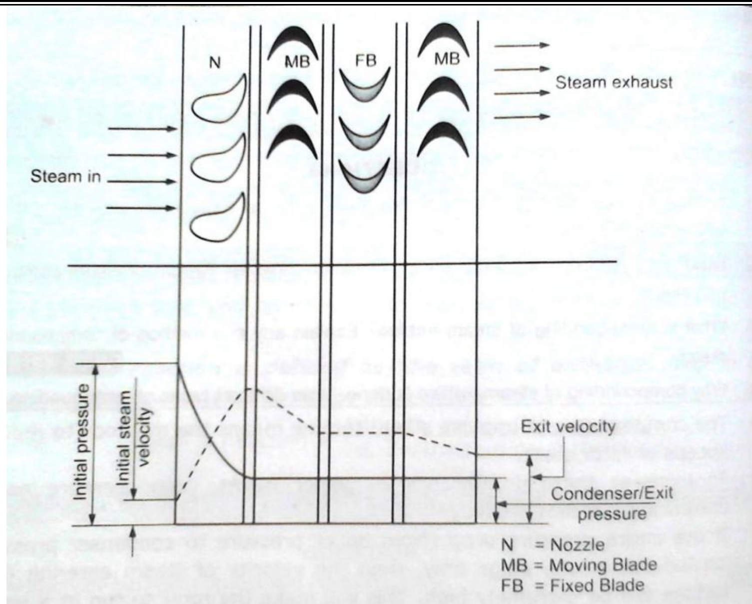


Figure: Velocity compounding

OR

iii) Pressure and Velocity Compounding:

- ✓ This method is combination of pressure compounding and velocity compounding.
- ✓ The total pressure drop of steam is divided into number of stages and velocity obtained in each stage is also compounded.
- ✓ A ring of nozzle is provided at the start of each stage.
- ✓ The nozzle ring is followed by two or more rows of moving blades and one or more rows of fixed or guide blades arranged alternatively.
- ✓ The steam from the boiler is passed through the first nozzle ring, where pressure drop occurs with increase in velocity of steam.
- ✓ The steam is now directed on the first moving blade, where the pressure of steam does not change, but small decreased in velocity occur.
- ✓ The steam is now allowed to pass through the guide or fixed blades, where its direction is changed.
- ✓ Now, the steam is directed on the second moving blade and procedure is repeated till the end of first stage.

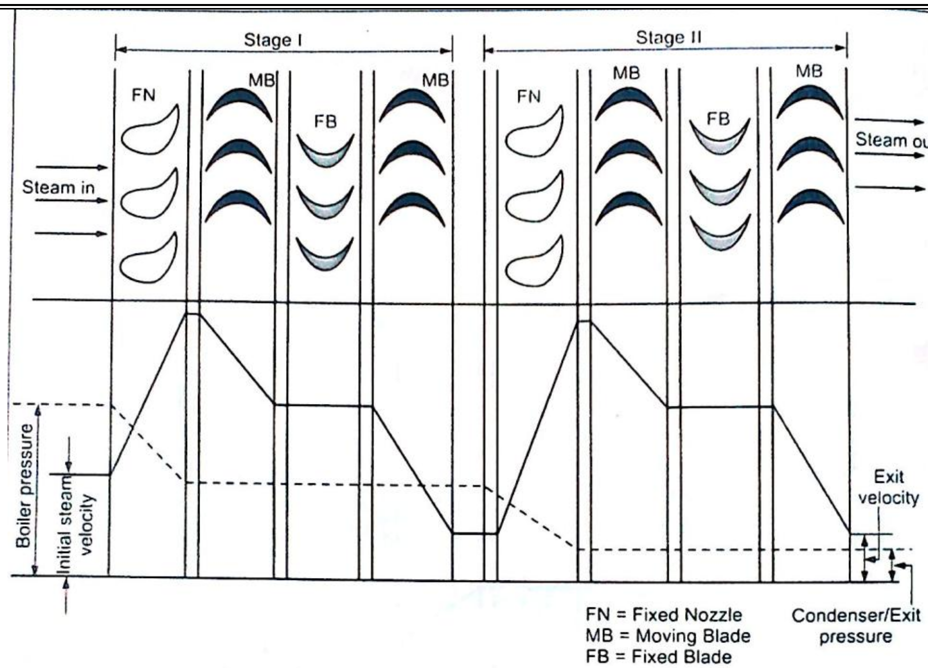


Figure: Pressure and Velocity compounding

c) **At the beginning of compression a cylinder contains 750 m^3 of gas at pressure of 100 KN/m^2 absolute. Compression takes place according to law PV^n=C. Untill pressure is 780 KN/M^2 absolute. If the final volume is 1/5 of original volume and find,** **08 Marks**

i. **Index of compression**
ii. **Work done during compression**
iii. **Heat rejected during compression**

Take Υ=1.4

Sol. Given Data:

$V_1 = 750\ m^3$

$P_1 = 100\ KN/m^2 = 100 X 10^3\ N/m^2$

$P_2 = 780\ KN/M^2 = 780 X 10^3\ N/m^2$ **02 Marks**

$V_2 = (1/5) X 750 = 150\ m^3$

$\Upsilon = 1.4$

(i) Index of compression: **02 Marks**

We have,

$P_1 V_1^n = P_2 V_2^n$

$(\frac{V_2}{V_1})^n = \frac{P_1}{P_2}$

Taking log on both sides,

$\log(\frac{V_2}{V_1})^n = \log(\frac{P_1}{P_2})$

$n \times \log(\frac{V_2}{V_1}) = \log(\frac{P_1}{P_2})$

$n \times \log(\frac{150}{750}) = \log(\frac{100 \times 10^3}{780 \times 10^3})$

n=1.276 **02 Marks**

(ii) Work done during compression:

$$W_{1-2} = \frac{P_1V_1 - P_2V_2}{n-1}$$

$$W_{1-2} = \frac{(100 \times 10^3 \times 750) - (780 \times 10^3 \times 150)}{1.276-1}$$

= -152 X 10^6 J **02 Marks**

(iii) Heat rejected during compression

$$Q_{1-2} = \frac{\gamma - n}{\gamma - 1} \times Work\ done$$

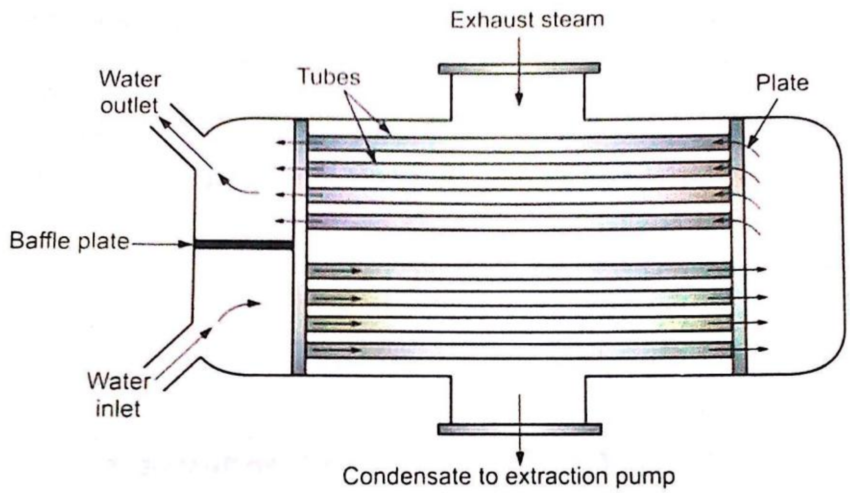
$$= \frac{1.4-1.276}{1.4-1} \times (-152 \times 10^6)$$

= -47.17 X 10^6 J

Q. 6.		**Attempt any TWO of the following.**	**16 Marks**
a)	**(i)**	**Compare jet and surface condenser on the basis of construction, performance and application.**	**04**
Sol.			

Parameters	Jet Condenser	Surface Condenser	
Construction	Condensing plant is simple to construct	Condensing plant is complicated to construct	**03 points 04 Marks**
Performance	Require less quantity of cold water	Require more quantity of cold water	

		Application	Less suitable for high capacity plant	More suitable for high capacity plant	

	(ii)	**Describe with sketch working of surface condenser.**	**04 Marks**
Sol.		 **Figure: Surface condenser**	**02 Marks for Figure**
		✓ In surface condenser, the cold water flows through the tubes and the steam passes over the tube as shown in figure. ✓ It consists of a horizontal cylindrical shell, having cover plates at the ends. ✓ The cylindrical shell comprises of number of parallel brass tubes. ✓ A baffle plate is used to divide the water box into two sections. ✓ The cold water enters the shell at the lower half section and after passing through the tubes, comes out from the upper half section. ✓ The exhaust steam enters the shell from the top side and passes over the tubes to get condensed. ✓ The condensate is finally removed by the extraction pump. ✓ Due to the reason that, steam flows in a direction right angle to the direction of flow of water and in the downward direction, this type of surface condenser can be called as cross surface condenser and down flow type.	**02 Marks for Working**
b)	**(i)**	**Draw temperature- entropy diagram for formation of steam and show the following on it.** **1) Saturated liquid line** **2) Wet-region** **3) Critical point** **4) Dryness fraction line**	**04 Marks**
Sol.			

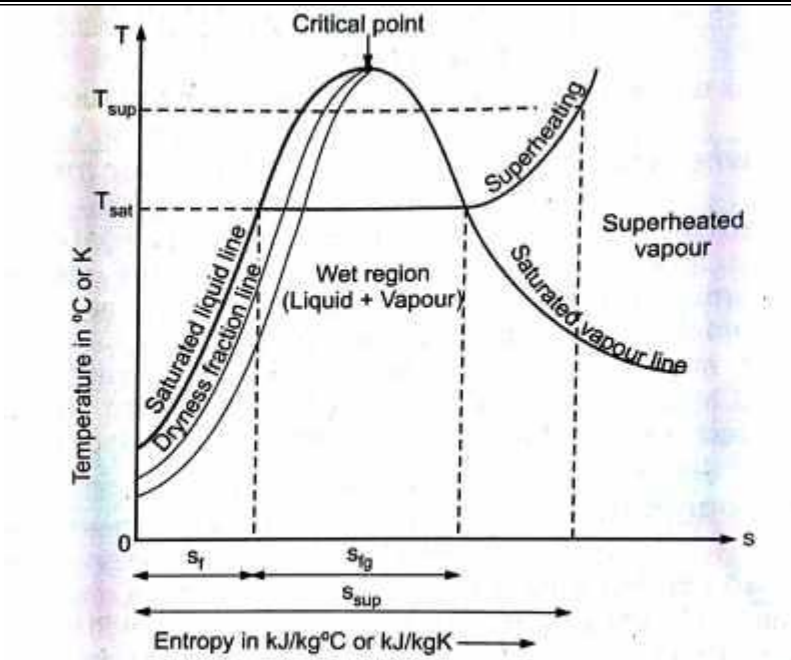


Figure: Temperature- entropy diagram

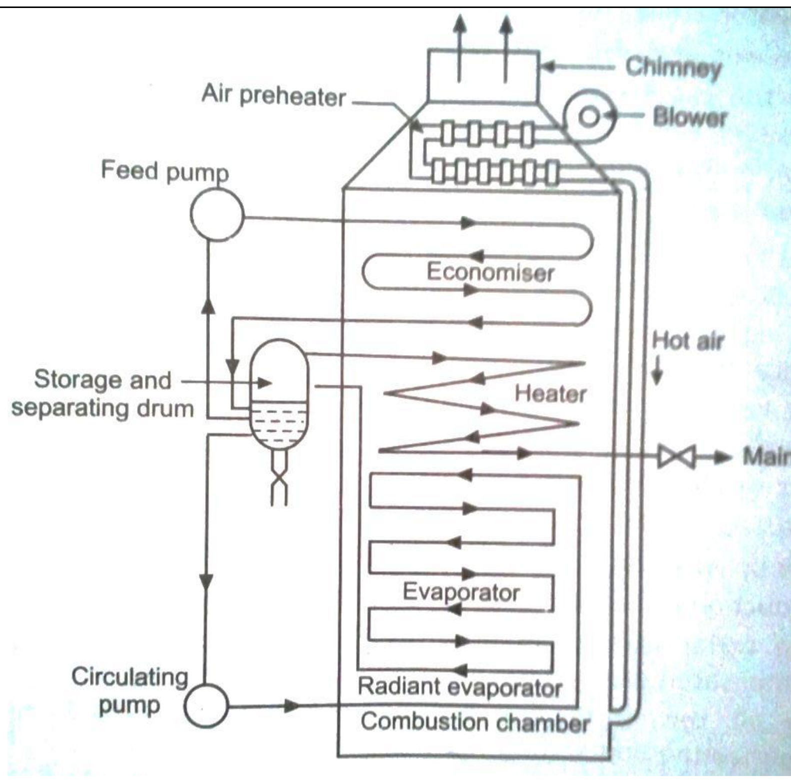
	(ii)	**Draw neat sketch of Lamont boiler.**	**04 Marks**
Sol.			

		Figure: Lamont boiler	
c)	**(i)**	**A metal pipe having diameter of 150 mm carries steam at 250^{0}C. the pipe is covered externally by the 25 mm thick of insulating material whose thermal conductivity is 0.112 W/mK. If outside temperature is 38^{0}C. Find out amount of heat lost per meter length per minute.**	**04Marks**
Sol.		Given Data : Diameter $= d_1 = 150$ mm $= 0.15$ m $r_1 = \frac{d_1}{2} = \frac{0.15}{2} = 0.075$ m  fig. metal pipe with insulation. $r_2 = r_1 +$ thickness of insulation $= 0.075 + 0.025 = 0.1$ m Thermal conductivity $= K = 0.112$ W/mk Length $= L = 1$ m $T_1 = 250^\circ c = 250+273 = 523$ K $T_2 = 38^\circ c = 38+273 = 311$ K. ∴ We have : $Q = \dfrac{T_1 - T_2}{\dfrac{\ln(r_2/r_1)}{2\pi L K}}$ $= \dfrac{523-311}{\dfrac{\ln\left(\frac{0.1}{0.075}\right)}{2\pi \times 1 \times 0.152}}$ **=569.41 watt** **Q= 34164.6 J/min.**	**02 Marks for Formula** **02 Marks for Answer**
	(ii)	**Give any four applications of heat exchangers and also state commonly used materials for it.**	**04 Marks**
Sol.		**Application of heat exchanger:** 1. Automobile radiator 2. Condenser coil in refrigerator 3. Air conditioner 4. cooling tower **Materials for heat exchanger:** 1. Aluminum 2. Stainless steel	**02Marks** **For application** **02 Marks** **For**

		3. Copper	**Materials**