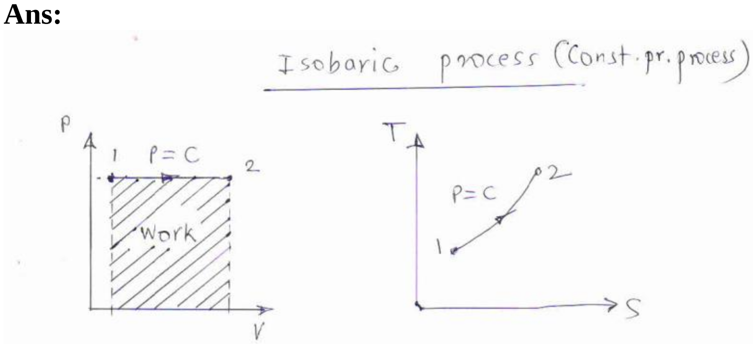
Important Instructions to examiners:

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.

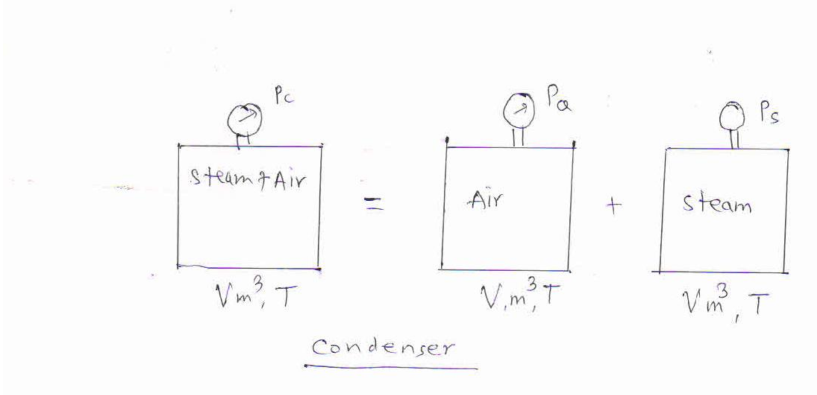
Q. No	sub	Answer	Marking Scheme
1.a		**Attempt any SIX of the following**	
	i	**Define path function and point function.** **Ans:** **Path function:** the thermodynamic quantities which are dependent on path followed between two end states of the process and independent of the two end states are called path functions. **Point function:** the property whose change depends on the initial and final state of system and not on the path adopted to bring about change is called point function.	1 1
	ii	**State Clausius statement of second law of thermodynamics.** **Ans: Clausius statement:** It state that " it is impossible to construct a heat pump , which while operating in a cyclic process, which will produce no effect other than transfer of heat from lower temperature reservoir to higher temperature reservoir .	2
	iii	**Represent Isobaric process on P-V and T-S charts.** **Ans:** 	01 for P-V and 01 for T-S
	iv	**State relationship between universal gas constant and characteristic gas constant. Write the meaning of each term.** **Ans:** The values of gas constant R are different for different gases. Universal gas constant doesn't depend on types of gases. For uniformity another unit of mass called Kg-mole is introduced. R= Characteristic gas constant = 287 J/KgK R_0= Universal gas constant = 8314.3 J/Kg-moleK $R= R_0/ \mu$	1 mark for values, 1 mark for relation

	v	**Differentiate between boiler mountings and accessories. (any two points)**	Any two points, 1 Mark each

Boiler mountings	**Boiler accessories**
Mountings are safety devices to control the steam generation process	Accessories are the auxiliary parts to increase overall efficiency of the boiler
Mountings are compulsory to be fitted	Accessories are optional
Example: - water level indicator, stop valve, blow off cock etc.	Example:- Economiser, air preheater, superheater.
They are mounted on boiler.	They increase boiler efficiency.

	vi	**State the meaning of terms 'governing' and 'compounding' of steam turbines.** **Governing**: Steam turbine governing is the procedure of controlling the flow rate of steam to a steam turbine so as to maintain its speed of rotation as constant. **Compounding:** the arrangement to reduce pressure from boiler pressure to condenser pressure by use of multiple system of rotors in series, keyed to common shaft or by increasing number of stages and the steam pressure or steam velocity is absorbed in stages as it flows over moving blades. This is known as compounding.	1 Mark 1Mark
	vii	**Write continuity equation of steam nozzle and state the meaning of each term.** It is the passage of varying cross sectional area in which heat energy of fluid is converted into kinetic energy. Applying S. F. E. E , $Q + h_1 + gZ_1 + (1/2)\, C_1^2 = W + h_2 + gZ2 + (1/2)\, C_2^2$ Since Q= 0, Z1, Z2= 0, W = 0 where, $h1 - h2 = (C^2 2/2) - (C^2{}_1/2)$ $2(h1 - h2) = C^2 2 - C^2{}_1$ $\mathbf{C2 = \sqrt{2\,(h1\text{-}h2) + C_1^2}}$ **Where** **C_1 :Velocity at inlet** **C_2: Velocity at exit** **h_1 : enthalpy at inlet** **h_2 : enthalpy at exit**	1 mark for equation 1 mark for meaning
	viii	**Define condenser efficiency.** **Ans:** it is defined as the ratio of temperature rise of cooling water to the vacuum temperature minus inlet cooling water temperature. $$\text{Condenser efficiency} = \frac{\text{Temp. rise of cooling water}}{\text{Vacuum temp.} - \text{Inlet cooling water temp.}}$$ $$\text{Condenser efficiency} = \frac{t_o - t_i}{t_v - t_i}$$ Where, to - Outlet temp. of cooling water. ti - inlet temp. of cooling water. tv - Vacuum temp . It is the saturation temp. Corresponding to the condenser pressure.	1 mark for definition, 1 mark for formula and meaning
1.b		**Attempt any TWO of the following**	
	i	**Define following terms:** 1) **Dryness fraction** 2) **Degree of superheat** 3) **Dry saturated steam** 4) **Superheated steam** **Ans:** 1) **Dryness fraction**:- It is defined as a fraction of steam that is in vapour form in liquid vapour is called dryness fraction.	1 mark for definition, 1 mark for formula and meaning of each

		$$X = \frac{Mv}{Mv + Ml}$$ Where x – Dryness fraction Mv – mass of vapour (dry steam) contain in steam ML = mass of water in suspension in steam *Dryness fraction is ratio of the mass of actual dry steam to the mass of wet steam.* 2)**Degree of superheat**: It is the difference between the temperature of superheated vapour & saturation temperature corresponding at given pressure. is said to be degree of superheat. Degree of superheat = (Tsup – Tsat) 3) **Dry saturated steam** It is defined as the quality of heat required to raise the temperature of one kilogram of water from freezing point to temperature of evaporation to convert it into dry saturated steam at that temperature & pressure. $H_s = H_f + H_{fg}$ Where Hs enthalpy of dry saturated steam H_f = sensible heat H_{fg} = latent heat of evaporation *The quantity of heat required to convert 1 kg of water at 0 ^{0}c into dry saturated steam at constant pressure is known as enthalpy of dry saturated steam.* **4)Superheated steam** An amount of heat required to one kg of water from freezing temperature into superheated steam is called enthalpy of superheated steam. $H_{sup} = H_f + H_g + C_{vs}(T_{sup} - T_{sat})$ Where H_{sup} = enthalpy of superheated steam H_f = sensible heat H_g = latent heat C_{vs} = specific heat of superheated vapour T_{sat} – saturated temperature *The quantity of heat required to convert 1 kg of water at 0 0c into superheated steam at constant pressure is known as enthalpy of superheated steam.*	
	ii	**State Dalton's law of partial pressures. Apply it to steam condenser with the help of suitable diagram.** **Ans: Dalton's law of partial pressure:** This law states that "The total pressure exerted by a mixture of air and water vapour on the walls of container is the sum of partial pressure exerted by air separated and that exerted by vapour separately at common temperature of the condenser". If there were no air present in the condenser the total pressure in the condenser would be equal to partial pressure of steam corresponding to temperature of condenser and in this case maximum vacuum would be obtained in the condenser. Hence, practically, the total pressure in the condenser is sum of partial pressures of exhaust steam and air present in the condenser. $$P = Pa + Ps$$ Where Pa= partial pressure exhausted by air Ps = partial pressure exhausted by vapour P = total pressure of mixture at temperature.	1 mark-definition, 1mark – equation, 1 mark-meaning, 1 mark – related diagram



iii **Define black body, grey body, emissivity, absorptivity.**

Ans:

Black body:

A body which absorbs all the incident radiation is called black body irrespective of its colour. For black body condition is $\alpha = 1$, $\beta = 0$, $\tau = 0$.

Grey body: If the body absorbs a definite percentage of incident radiation irrespective of their wavelengths, the body is known as 'grey body'.

Emissivity: it is defined as total emissive power to total emissive power of a black surface, at the same temperature.

Absorptivity: It is defines as the ratio of amount of energy absorbed to amount of energy incident on a body

OR

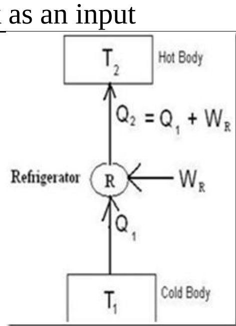
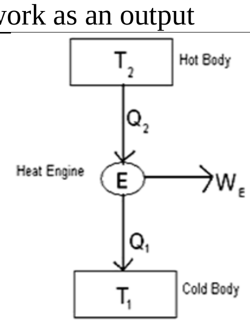
Fraction of total energy absorbed by the body is called Absorptivity.

2mark to each definition

2 **Attempt any FOUR of the following**

a **Differentiate between heat engine and heat pump. (any four points)**

any 4 points, 1 mark to each

Heat pump	**Heat engine**
thermodynamic system which transfers heat from low temperature body and gives out the same to high temp body.	thermodynamic system which transfers heat from high temperature body and gives out the same to low temp body.
it works between hot body temp and atmospheric temp	it works between hot body temp and reservoir temp.
$(COP)_{HP} = Q_1/Q_1-Q_2$	$(COP)_{HE} = Q_2/Q_1-Q_2$
COP of heat pump is greater than 1	COP of heat engine is always less than 1
in case of HP atmosphere acts as a cold body	in case of HE source acts as a hot body
it takes work as an input	it gives work as an output
	

b **A tank of 2.2 m^3 capacity contains air at 260^{0}C and 0.1 MPa. Some air is taken from the tank without changing temperature until pressure becomes 4 KPa. Calculate:**

(i) Mass of air left in the tank.

(ii) Mass of air pumped out. (take R= 0287 KJ/Kg^{0}K)

04 marks

Ans: Given

<table>
<tr><td></td><td></td><td>
V_1= 2.2 m^3 ,
T_1= 260^0C ,
P_1= 0.1 MPa ,
P_2= 4 KPa
Tank volume and air temperature remains constant as tank capacity will not change.
$P_1V_1=m_1RT_1$
$m_1= P_1V_1 / RT_1$
m_1= (0.1* 10^3*2.2)/(0.287*(260+273))
m_1= 1.438 Kg
$m_2= P_2V_2 / RT_2$
m_2= (4*2.2)/(0.287*(260+273))
m_2= 0.05752 Kg
hence,
i) Mass of air left in the tank= 1.438 Kg
ii) Mass of air pumped out= 0.05752 Kg
</td><td></td></tr>
<tr><td></td><td>c</td><td>
What is boiler draught? State various types of boiler draughts with meaning.
Ans: The small static pressure difference which causes a flow of gas to take place is termed as a draught.
OR
The difference of pressure required to maintain the constant flow of air and to discharge the gases through the chimney to atmosphere is known as boiler draught.
OR
Boiler draught is the pressure difference, which is necessary to draw the required quantity of air for combustion and to remove the flue gases out of the boiler combustion chamber.

Necessity of boiler draught
1. To provide sufficient quantity of air for combustion.
2. To expel out the hot gases to flow through the boiler.
3. To discharge these gases to atmosphere through chimney.
Boiler draught is classified as: -
1. Natural or chimney draught: draught is produced with the help of chimney alone by using pressure difference between hot flue gases inside the chimney and cold air outside the chimney.
2. Artificial draught
a) Fan draught (Produced by mechanical fan) : draught is produced with the help of fan
i) Forced draught: fan is kept before boiler furnace.
ii) Induced draught: fan is kept after boiler furnace and before the chimney.
iii) Balanced draught
b) Steam jet draught (Produced by steam jet)
i) Induced draught
ii) Forced draught
</td><td>1 mark for definition , 3 marks for classification with meaning</td></tr>
<tr><td></td><td>d</td><td>
Compare impulse and reaction turbine on the basis of following points:
(i) Shape of blade
(ii) Admission of steam
(iii) Power generated
(iv) Speed
Ans:
<table>
<tr><th>Sr. No.</th><th>Parameter</th><th>Impulse turbine</th><th>Reaction turbine</th></tr>
<tr><td>1</td><td>Shape of blade</td><td>symmetrical profile</td><td>Asymmetrical profile. i.e. aerofoil shape</td></tr>
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</td><td>1 mark each for 4 points</td></tr>
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2	Admission of steam	steam completely expand in nozzle and pressure remain constant during flow through blade passage	Steam expands partially in nozzle and further expansion takes place in rotor blades passage.	
3	Power generated	less	high	
4	Speed	higher	lower	

e **Enlist various losses in steam turbines.**

Ans:

Losses in steam turbine

1. Residual velocity loss
2. Loss due to friction
3. Leakage loss
4. Loss due mechanical friction
5. Radiation loss
6. Loss due to moisture

1 marks each to any 4 points

f **Write steady flow energy equation and apply it to boiler and nozzle.**

Ans:

steady flow energy equation

Q + h1 +gZ1 + (1/2) $C^2$1 = W+h2+gZ2+(1/2) $C^2$2

Turbine

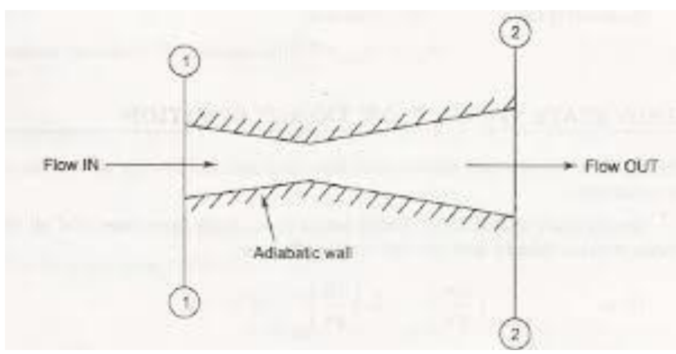


Fig. shows a commonly used convergent-divergent nozzle.

For this system,

$$\Delta PE = 0$$
$$W = 0$$
$$Q = 0$$

Applying the energy equation to the system,

$$h_1 + \frac{C_1^2}{2} = h_2 + \frac{C_2^2}{2}$$

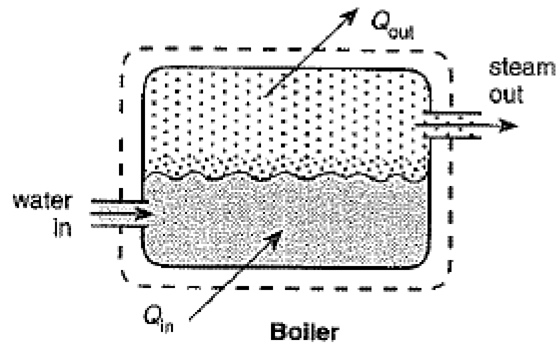
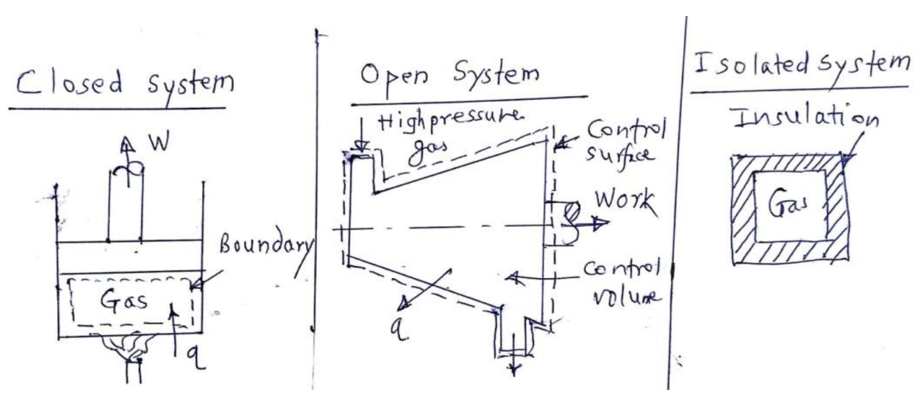
or $$\frac{C_2^2}{2} - \frac{C_1^2}{2} = h_1 - h_2 \quad \text{or} \quad C_2^2 - C_1^2 = 2(h_1 - h_2)$$

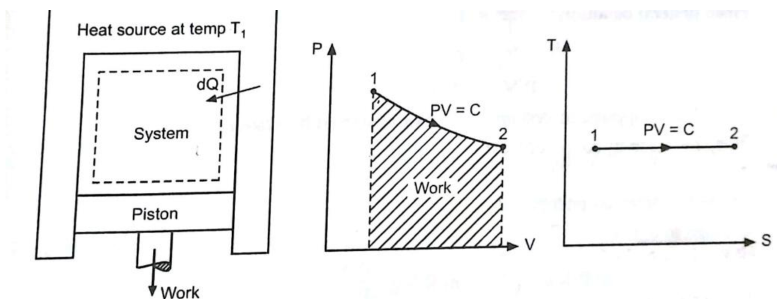
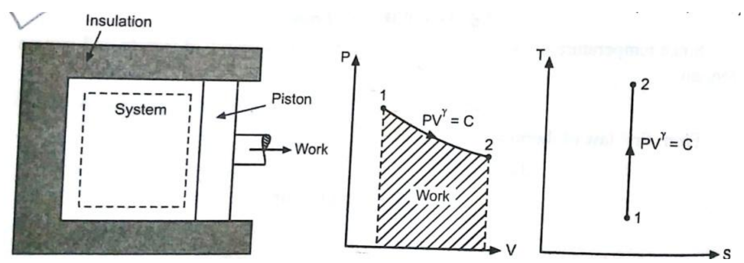
or $$C_2^2 = C_1^2 + 2(h_1 - h_2)$$

$$\therefore \quad C_2 = \sqrt{C_1^2 + 2(h_1 - h_2)}$$

where velocity C is in m/s and enthalpy h in joules.

2 mark- steady flow energy equation, 1 marks – application to turbine, 1 marks – application to boiler

		Boiler:  **Assumptions:** **ΔP.E=0** **W=0** **ΔK.E=0** **Answer:** **$Q = h_2 - h_1$** **heat supplied is utilized to increase enthalpy**	
Q3		**Attempt any FOUR (4 X 4 =16)**	16
	a	The thermodynamic system is defined as a prescribed region, or space or finite quantity of matter surrounded by an envelope called boundary. The boundary may be real physical surface/imaginary, fixed/moving. Types of system are – [1 Mark] 1.Closed system(Non-flow system) – In closed system mass within the boundary of the system remains constant and only energy (i.e. heat and work) may transfer across the boundary. It can be explained with the concept of boundaries e.g. piston and cylinder arrangement without valve [1 Mark]  2. Open system-The system is called open if mass as well as energy (i.e. heat and work) transfer across boundaries. Such system is described with the help of control volume and control surface. e.g. steam turbine, compressor, I.C. engine [1 Mark] 3. Isolated system -When no flow of heat, work and mass takes place across the 11boundaries, the system is termed as isolated system. . It can be explained with the	04

		concept of boundaries e.g. Gas enclosed in insulated vessel. [1 Mark]	
	b	Isothermal process – Constant temperature process, ideal process, and piston moves very slow. It obeys the law PV=constant [2 Mark]  Adiabatic process-No heat transfer between system and surrounding , dQ =0  Piston moves very fast, entropy remains constant in ideal adiabatic process. Work is done at the cost of internal energy. It obeys the law PV^{γ} =Constant [2 Mark]	2 + 2
	c	Cochran Boiler [4 Mark]	4

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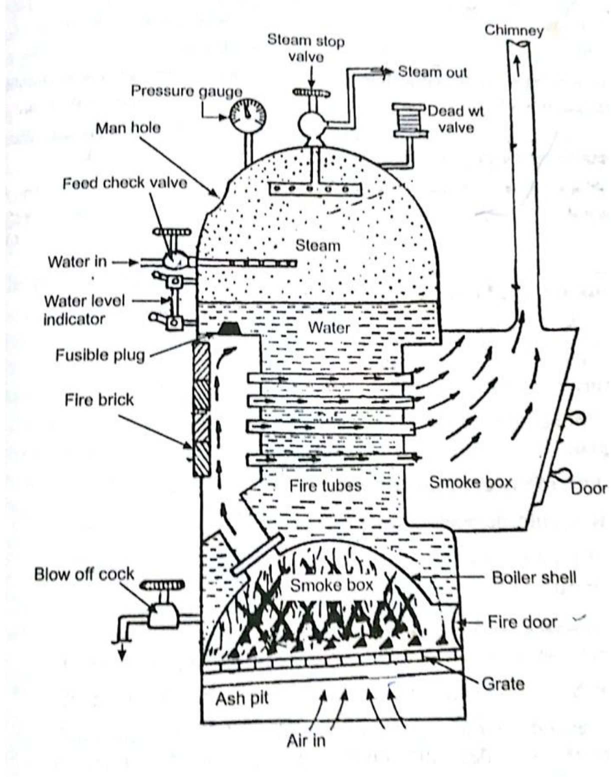

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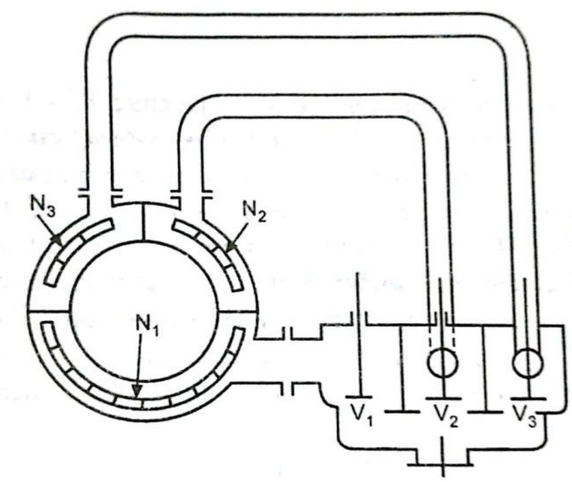
<tr><td></td><td>d</td><td>
a) Nozzle control Governing of steam turbine [Sketch 2+Explanation 2 Mark]



The function of governing is to regulate the supply of steam to the turbine so that speed should remain constant in varying load condition. In nozzle control governing, the nozzles are made in groups and the supply of steam to each group is controlled by regulating a valve. The nozzles are divided into three groups N1, N2, N3 and respective control valves are V1,V2,V3 that control the steam supply to corresponding nozzles. The number of nozzles in a group may be three, five or ten. Under full load condition, all the regulating valves are open, when the load on the turbine is reduced, the suitable valve is closed to reduce the supply of steam.
</td><td>2+2</td></tr>
<tr><td></td><td>e</td><td>Comparison [1 Mark for each point]</td><td>1+1+1+1</td></tr>
</table>

SR. NO	CRIERIA	JET CONDENSER	SURFACE CONDENSER
1	Amount of cooling water required	Less amount of cooling water is required	More amount of cooling water is required
2	Vacuum efficiency	Vacuum efficiency is less due to mixing of cooling water and exhaust steam	Vacuum efficiency is more due to non mixing type operation
3	Construction	Simple and suitable for small capacity plant	Complex and suitable for large capacity plant
4	Operation of heat exchange	Direct contact type ,as mixing of cooling water and exhaust steam occurs	Indirect contact type ,as no mixing of cooling water and exhaust steam

Q.	Sub Q.	Answer	Marks
	f	Heat exchanger-A heat exchanger is a device, which transfers thermal energy between two fluids at different temperatures. In most of the thermal engineering applications, both of the fluids are in motion and main mode of heat transfer is convection. Examples are automobile radiators, condenser coil in refrigerator, air conditioner, solar water heater, chemical industries, domestic boilers, oil coolers in heat engine, milk chillers in pasteurizing plant. [1 Mark for 1 example]	1+1+1+1
Q4		**Attempt any four**	16
	a	Equivalence of Kelvin Plank statement and Clausius statement of Second Law of Thermodynamics [Sketch 2+Explanation 2 Mark]	2+2

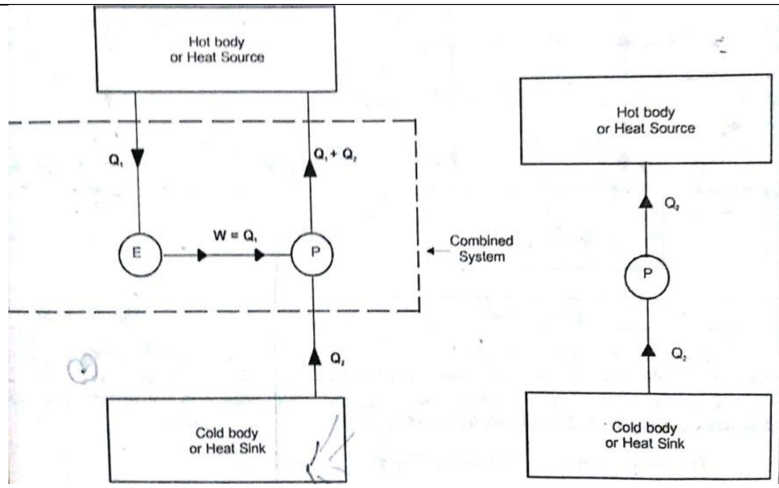
Though Kelvin Plank statement and Clausius statement of Second Law of Thermodynamics seems to be different, they are equivalent to each other. This can be proved by- violation of one statement leads to violation of another and vice versa. **[Student can prove it by violating any one of them]**

Violation of Kelvin Plank statement:-

Consider a heat engine having 100% efficiency (i.e. PMM-II) i.e. violating Kelvin Plank statement. Such a heat engine will convert the heat energy supplied Q1 into equivalent amount of work (W).

$\therefore$ Q1 =W

This work done produced can be utilized to drive a heat pump which receives amount of heat Q2 from cold body (Heat sink)and rejects an amount of heat (Q1+Q2) to hot body (Hot thermal reservoir) as shown in fig.



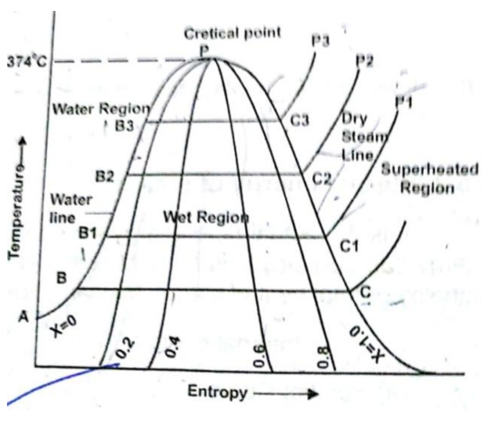
If combination of a heat engine and heat pump is considered as a single system, the result will be a device (Such as heat pump) , which delivers Q2 heat from cold body to hot body without having any external work done, which is impossible according to Clausius statement.

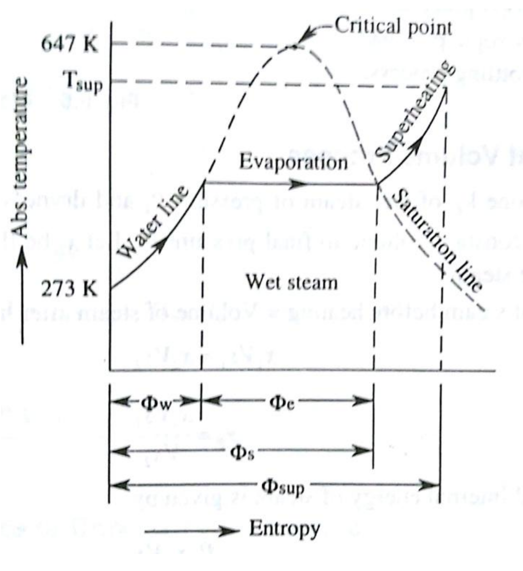
Hence violation of Kelvin Plank statement violates Clausius statement. Hence equivalence is proved.

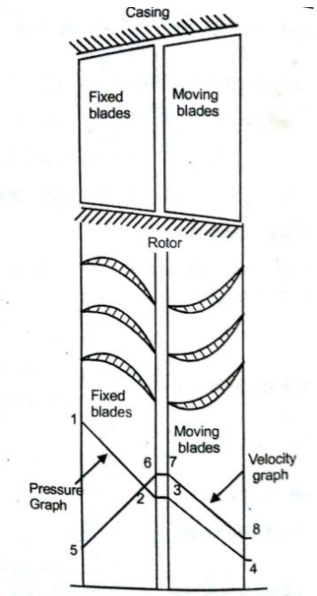
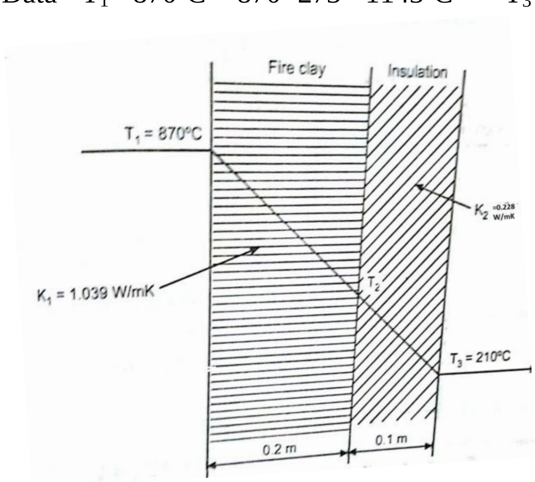
b

Representation of Steam generation process on T-S diagram [Sketch 3+Explanation 1 Mark] **3+1**

Fig shows Temperature- Entropy diagram when 1 kg of water is heated at constant pressure until the water is converted into superheated steam. The absolute temp is plotted vertically and entropy is plotted horizontally. The diagram has three regions. These are represented by two lines- water line (liquid line) and saturation line. These two lines meet at a point which is known as critical point.The temperature corresponding to this point is 374^0 C and 220.7 bar. **[Any one diagram is acceptable]**





	c	Working principle of Reaction turbine with sketch. [Sketch 2+Explanation 2 Mark]  In this type of turbine , there is gradual pressure drop and takes place continuously over the fixed and moving blades. The function of fixed blades is same as nozzle. They alter the direction of steam as well they allow steam to expand to have larger velocity. As the steam passes over the moving blades K E is obtained due to fall in pressure. The steam expands while flowing over the moving blades and thus give reaction to the moving blades. Hence the turbine is known as reaction turbine. Since the pressure drop is gradual, the number of stages required are more, for the same power developed.	2+2
	d	Composite wall Data- $T_1 = 870^0C = 870+273 = 1143^0C$ $T_3 = 210^0C = 210+273 = 483^0C$  Rate of heat flow per unit area $$\frac{Q}{A} = \frac{T1 - T3}{\frac{L1}{K1} + \frac{L2}{K2}}$$	2+2

		$= \dfrac{1143 - 483}{\dfrac{0.2}{1.039} + \dfrac{0.1}{0.228}}$ = 1046.124 W/m^2 [2 Mark] Interface temperature Heat transfer /unit area for fire clay wall $\dfrac{Q}{A} = \dfrac{T1-T2}{\frac{L1}{K1}}$ $1046.124 = \dfrac{1143-T2}{\frac{0.2}{1.039}}$ T_2= 941.628 K = 941.628-273 = 668.62 ^{0}C [2 Mark]	
	e	Vacuum efficiency of Condenser Data- Vacuum reading or actual vacuum = 710 mm of Hg Barometer reading = 760 mm of Hg Hot well temperature = 30 ^{0}C We know that pressure in the condenser = 760- 710 = 50 mm of Hg From steam tables, corresponding to a temp. of 30 ^{0}C, ideal pressure of steam = 0.0424 bar=$\frac{0.0424}{0.00133}$ =31.88 mm of Hg Now, Ideal vacuum = Barometric reading –Ideal pressure =760-31.88 = 728.12 mm of Hg [2 Mark] Vacuum efficiency =η_{vacuum} = $\frac{Actual\ vacuum}{Ideal\ vacuum}$ =$\frac{710}{728.12}$ = 0.9751 = 97.51% [2 Mark]	2+2
	f	Enthalpy of Wet steam = H_{wet} = h + x L [1 Mark] h = Sensible heat in KJ/ Kg L= Latent heat in KJ/Kg ; x = dryness fraction Enthalpy of Superheated steam = H_{sup} = h + L + C_p (T_{sup}-T_{sat}) [1 Mark] C_p= Specific heat of Superheated steam in KJ/ Kg T_{sup} = Temperature of Superheated steam T_{sat} = Saturation temperature corresponding to pressure of steam generation Entropy of Wet steam = S_{wet} = S_w +x(S_s-S_w) [1 Mark] Entropy of superheated steam= S_{sup} = S_s + C_p $\log_e \frac{Tsup}{Tsat}$ [1 Mark] S_s= Entropy of dry saturated steam	1+1+1+1
5.		**Attempt any <u>TWO</u> of the following:**	
a)	**i**	**Differentiate between heat and work.**	

	Heat	Work	
1	Form of energy that is transferred between system and surrounding or two systems due to temperature difference.	The amount of energy transferred by a force acting though a distance.	**1 Mark for each difference.**
2	Heat is a function of the state.	Work is function of path.	
3	Heat is energy interaction due to temperature difference.	Work is energy interaction by reasons other than temperature difference.	
4	The heat is form of energy. A unit of heat is joule.	The work is form of energy. Units of work are joule.	

ii **Explain Zeroth law of thermodynamics.**

"If two systems are each is thermal equilibrium with a third system, then the two systems are also in thermal equilibrium with one another."

This law was enunciated by R.H. Fowler in 1931 however since the first and second law already existed at that time it was designated as Zeroth law so that it precedes the first and second law to form a logical sequence.

2 Marks for Statement

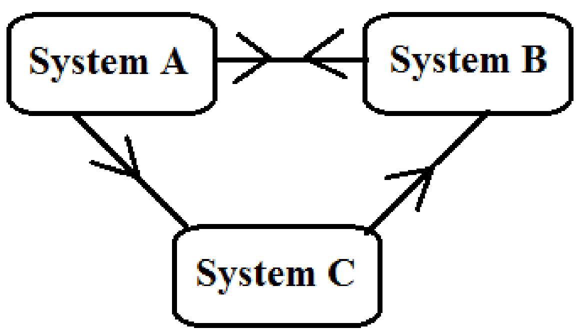


Figure: Zeroth law of thermodynamics

2 Marks Figure and explanation

If System A and System C and System B and System C are thermal equilibrium with each other then system A, B are also in thermally equilibrium with each other.

b) **Sketch and explain pressure compounded and velocity compounded impulse turbine showing pressure and velocity variations along the axis.** **8 Marks**

Sol.		**i) Pressure Compounding:** ✓ Compounding is the method adopted to reduce the speed of turbine rotor at the same time to utilize internal energy of steam effectively. ✓ This method is the combination of pressure and velocity compounding to get benefit of both methods. ✓ Arrangement of blades and nozzles are made as below; N-M-N-M-N-M Where; N = Nozzle MB = Moving blade ✓ 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.	**2 Marks**

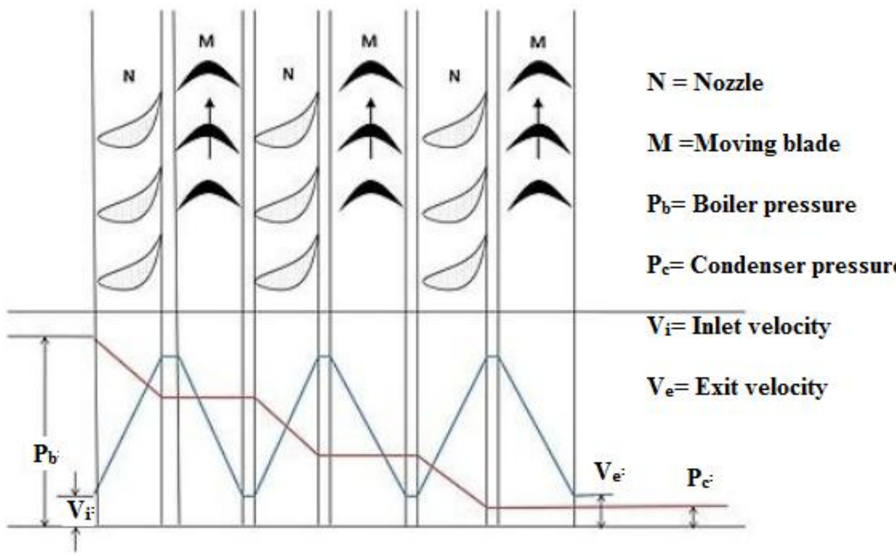
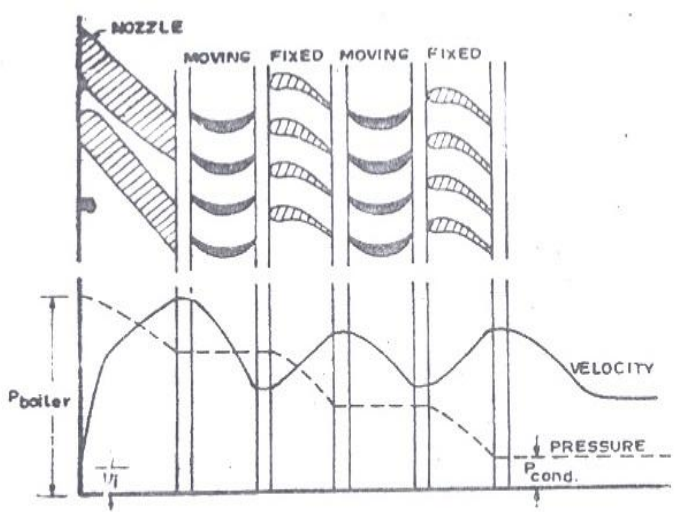


Figure: Pressure compounding

2 Marks

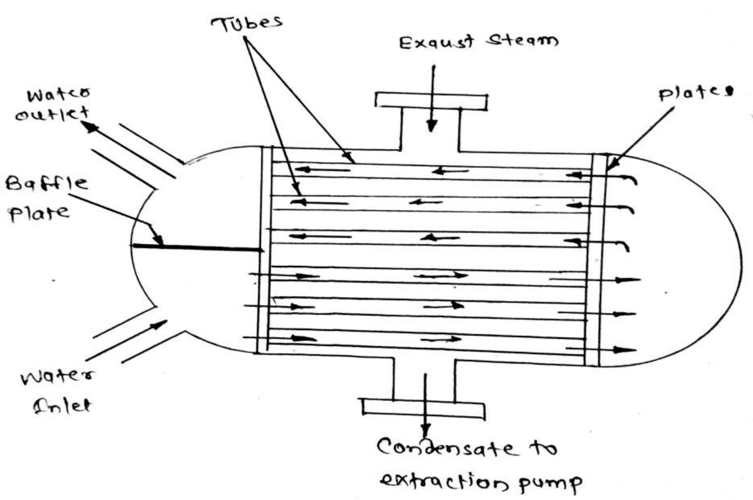
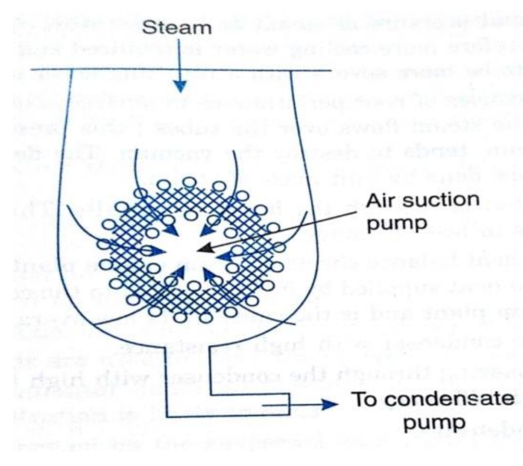
ii) Velocity Compounding:

2 Marks



- ✓ 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.

	C.	**A certain gas has C_P=1.968 KJ/kgK and C_V=1.507 KJ/kg K. Find its molecular weight and the gas constant. A constant volume chamber of 0.3 m^3 capacity contains 2 kg of this gas at 5^0C Heat is transferred to the gas until the temp is 100^0C. Find work done, heat transfer and change in internal energy.**	
		Characteristics gas constant R is;	
		$R = C_P - C_V$	
		$R = 1.968 - 1.507$	**2 Marks**
		$R = 0.461$ KJ/kgK	
		Universal gas constant R_U is;	
		$R_U = 8.314$ KJ/kg − mole K	
		$R_U = MR$	
		So, Molecular weight M is;	
		$M = {}^{8.314}/_{0.461}$	
		$M = 18.03$ kg − mole	
		$T_1 = 5°C = 5 + 273 = 278$ K	
		$T_2 = 100°C = 100 + 273 = 373$ K	**2 Marks**
		In Constant volume process i.e. Isochoric process Work done is zero.	
		So;	
		1. Workdone	
		$dW = 0$	
		2. *Heat transfer*	**2 Marks**
		$dQ = m\,C_V\,(T_2 - T_1)$	
		$= 2 \text{ X } 1.507 \text{ X } (373 - 278)$	
		$= 286.33$ KJ	
		3. *Change in Internal energy*	**2 Marks**

6.		**Attempt any TWO of the following.**	**16 Marks**
a)	**i**	**Draw neat sketch of any one type of surface condenser. Label parts.**	
		Classification of surface condenser: i. Down flow type ii. Center flow type iii. Inverted flow type iv. Regenerative type v. Evaporative type  **Figure: Down flow type**  **Figure: Center flow type**	**2 Marks** **For Figure.** **2 Marks for Label of parts.** **Any one…**

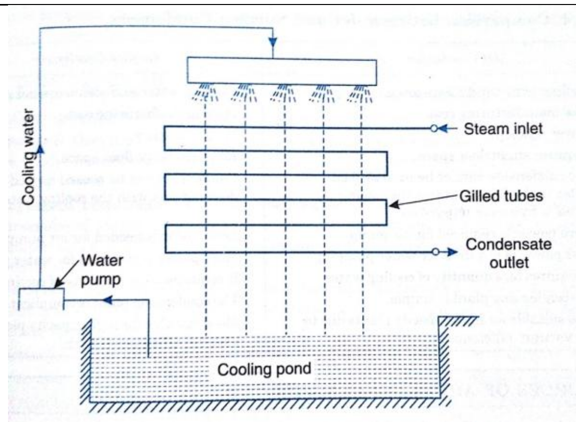


Figure: Evaporative type

*** Any one of them**

	ii	**State any two sources and effects of air leakage into steam condenser.**	**4 Marks**
		✓ The main sources of air found in condenser are given below: 1) There is leakage of air from atmosphere at the joint of the parts which are internally under a pressure less than atmospheric pressure. 2) Air is also accompanied with steam from the boiler into which it enters dissolved in feed water. 3) In jet condensers, a little quantity of air accompanies the injection water. ✓ The following are the effects of air leakage in a condenser: 1) Lowered thermal efficiency 2) Increased requirement of cooling water. 3) Reduced heat transfer. 4) Corrosion.	**2 Marks** **2 Marks**
b)	**(i)**	**A sample of 3 kg. of steam at a pressure of 3 MPa exists in dry and saturated condition. For this sample, calculate enthalpy and entropy using steam table.**	**4 Marks**
Sol.		Properties of steam from Steam table; Mass of steam = $3\ kg.$ Pressure = $3MPa = 30\ bar$ So; Specific enthalpy of dry saturated steam; $h_g = 2802.3\ KJ/kg$	

		Enthalpy of 3 Kg of steam $= 3\ X\ 2802.3 = \mathbf{8406.9\ KJ/kg}$ Specific entropy of dry saturated Steam; $S_g = 6.1837\ KJ/kg$K Entropy of 3 Kg of steam $= 3\ X\ 6.1837$ $= \mathbf{18.551\ KJ/kg}$**K**	**2 Marks** **2 Marks**
	ii	**Steam at 8 bar and 0.85 dry is throttled to a pressure of 1 bar.**	
		Find final quality of steam. Use steam table. Properties of steam from Steam table; **<u>At 8 bar:</u>** **Specific enthalpy:** $h_{f1} = 720.9$ KJ/kg $h_{fg1} = 2046.5$ KJ/kg **Specific entropy:** $S_{f1} = 2.0457$ KJ/kgK $S_{fg1} = 4.6139$ KJ/kgK **<u>At 1 bar:</u>** **Specific enthalpy:** $h_{f2} = 477.5$ KJ/kg $h_{fg2} = 2257.9$KJ/kg **Specific entropy:** $S_{f2} = 1.3027$ KJ/kgK $S_{fg2} = 6.0571$ KJ/kgK	**1 Mark**

		In throttling process enthalpy is constant: $$\text{Enthalpy at 8 bar} = \text{Enthalpy at 1 bar}$$ $$h_1 = h_2$$ $$h_{f1} + x_1\, h_{fg1} = h_{f2} + x_2\, h_{fg2}$$ $$720.9 + 0.85 \text{ X } 2046.5 = 477.5 + 2257.9\, x_2$$ $$\boldsymbol{x_2 = 0.878}$$ **Initial entropy;** $S_1 = S_{f1} + x_1\, S_{fg1}$ $S_1 = 2.0457 + 0.85 \text{ X } 4.613$ $S_1 = 5.966 \text{ KJ/kgK}$ **Final entropy;** $S_2 = S_{f2} + x_2\, S_{fg2}$ $S_2 = 1.3027 + 0.878 \text{ X } 6.0571$ $S_2 = 6.621 \text{ KJ/kgK}$ At 1 bar specific entropy S_2 is between S_{fg} and S_g, so quality of steam is dry .	**1 Mark** **2 Marks**
c)		**Explain various modes of heat transfer with suitable example.**	**8 Marks**
		Modes of heat transfer: Heat transfer takes place by the following three modes. 1) Conduction 2) Convection 3) Radiation. **1) Conduction:** Conduction is the transfer of the heat from one part of a substance to another part of same substance or from one substance to another substance in physical contact with it. **E.g.** 1) Fins provided on motor cycle engine. 2) Heating a metallic rod at one end and sense the heat at other end.	**2 Marks** **2 Marks**

		2) Convection: Convection is the transfer of heat within a fluid by mixing of one portion of the fluid with another. Convection is possible only in a fluid medium and is directly linked with the transport of medium itself.	**2 Marks**
		E.g. Boiling water **-** The heat passes from the burner into the pot, heating the water at the bottom. Then, this hot water rises and cooler water moves down to replace it, causing a circular motion.	**2 Marks**
		3) Radiation: Radiation is the transfer of heat through space or matter by means other than conduction or convection. Radiation is heat through of as electromagnetic waves. All bodies radiate ; so a transfer of heat radiation occurs because hot body emits more heat than it receive and cold body more heat than it emits. Radiation energy required no medium for transfer and will pass through vacuum.	**2 Marks**
		E.g. 1) Heat from the sun warming your face 2) Heat from a light bulb 3) Heat from a fire 4) Heat from anything else which is warmer than its surroundings.	