WINTER – 19 EXAMINATION

Subject Name: Thermal Engineering **Model Answer** **Subject Code:** 17410

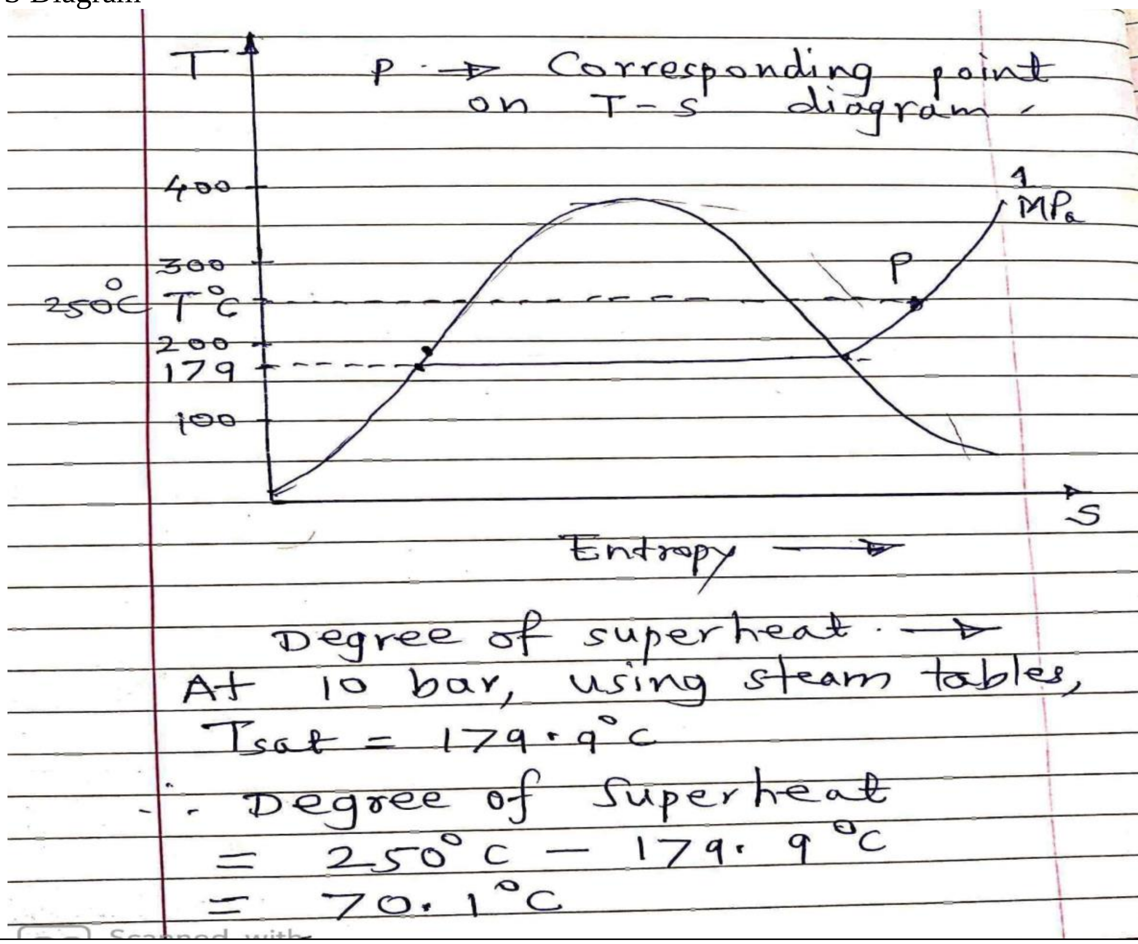
Important Instructions to examiners:

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.1.		**Attempt any SIX of the following:**	**12 Marks**
a)	**i)**	**In a boiler enthalpy of water supplied was 2000 kJ/kg. Enthalpy being added by fuel combustion is 3200 kJ/kg. Using first law of thermodynamics, find amount of heat supplied if steam generation rate is 10 tons per hour.**	
	Sol.	Heat supplied $Q = m (h_2-h_1)$ …….(Steady flow energy equation for boiler) ; h_2=3200 KJ/kg h_1=2000 KJ/kg m = 10 Tons /hour = (10 x 1000)/3600 kg/sec = 2.77 Kg/sec Q = 2.77(3200-2000) = 3324 KJ/sec heat supplied for 10 Tons/hr steam generation	**01 Mark** **01 Mark**
	ii)	**Find molar volume of air when volume of a container in which air is contained is 3 m^3 where as mass of air is 3.81 kg. Take molecular weight of air 29.**	
	Sol.	Molar Volume:- Volume = 3 m^3; mass = 3.81 kg 3.81 kg in 3 m^3 ; 3810 gm in 3 m^3 3810/29 moles in 3m^3 Molar volume = 3810 / (3 x 29) = 43.79 mol/m^3 Molar volume = Volume occupied by 1 mole 43.79 moles in 1 m^3 1 mole in (1/43.79) m^3 = 0.0228m^3 = 22.8 Litre	**01 Mark** **01 Mark**

iii) **Steam is available at turbine inlet at 10 bars and 250°C. Locate point on T-S diagram. Find degree of superheat.**

Sol. `T-S Diagram — **01 mark**, **01 mark**



iv) **Comment on Mach number of steam in impulse and reaction turbines.**

Sol. Mach number, in fluid mechanics, ratio of the velocity of a fluid to the velocity of sound in that fluid. Mach numbers less than one indicate subsonic flow; those greater than one, supersonic flow. — **01 mark**, **01 mark**

v) **State two factors on which efficiency of cooling tower depends.**

Sol. Efficiency of cooling tower depends on — **Any two 1 mark each**

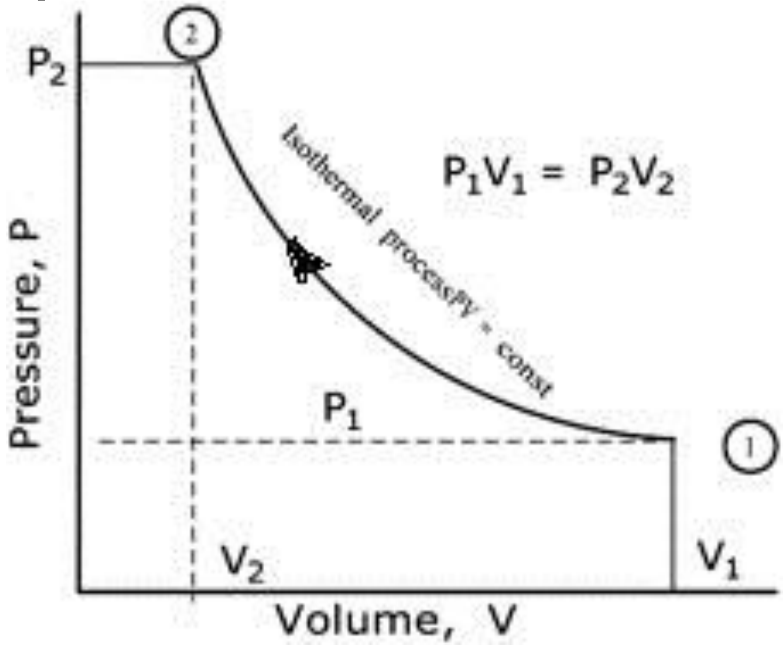
1.Losses in duct, piping and joints, pipes should be free from scale/rust
2.Efficient heat transfer, maintenance of piping , Ensure fill is clean and free of debris.
3.Sufficient airflow and correct fan speed.

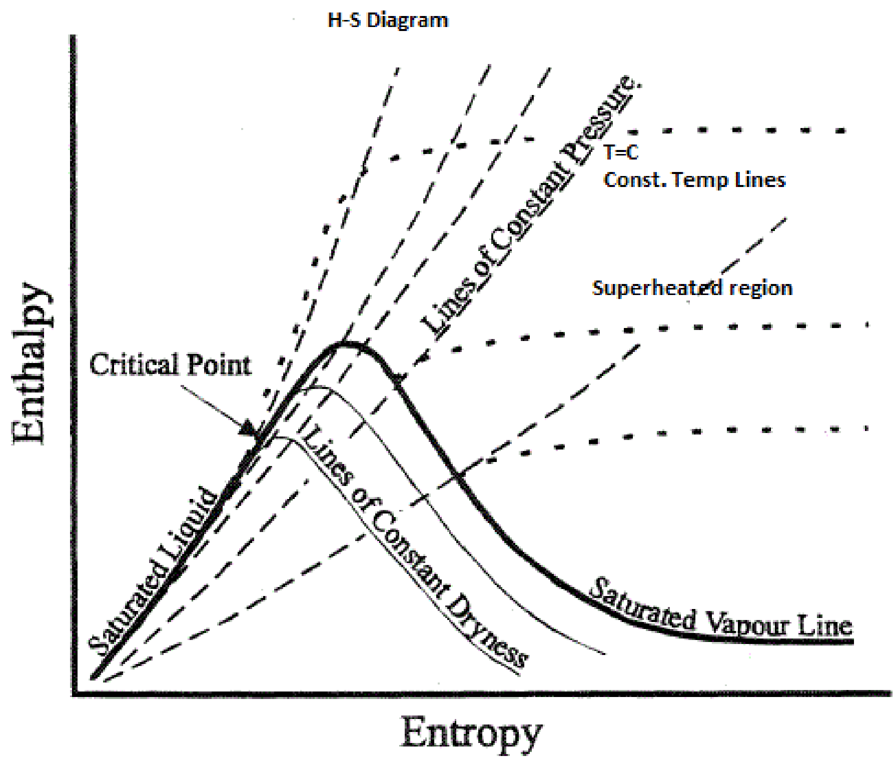
vi) **Identify modes of heat transfer involved applications with brief explanation.**
(1) Radiator of automobile
(2) Condenser of domestic refrigerator.

Sol. Modes of heat transfer

Automobile radiator-A radiator is a type of heat exchanger. It is designed to transfer heat from the hot coolant that flows through it to the air blown through it by the fan. Heat transfer from a radiator occurs by all the usual mechanisms: thermal radiation, convection into flowing air or liquid, and conduction into the air or liquid. — **01 mark**

Condenser of refrigerator- The Condenser is a heat transferring device. It is used to remove heat from hot refrigerant vapour. Using air cooling method condenser changes the vapour to a liquid. Convection mode of heat transfer plays very important deciding factor transferring heat from condenser tube to atmosphere. — **01 mark**

	vii)	**Categorize point and path functions from following. (pressure, heat, internal energy, temperature, work, total enthalpy.)**	
	Sol.	Point function-Pressure, temperature, internal energy, total enthalpy Path function-Heat, Work	**01 mark** **01 mark**
	viii)	**A gas is compressed from 1 bar and 30°C to 5 bars and 30°C. Identify process and show on PV diagram.**	
	Sol.	Gas is compressed from (1) 1 bar 30 ^{0}C to (2) 5 bar 30 ^{0}C Temp is constant. Hence process is isothermal. P x V = Constant  	**01 mark** **01 mark**
b)		**Attempt any <u>TWO</u> of the following:**	**08 Marks**
	i)	**Describe thermodynamic equilibrium with two suitable examples.**	
	Sol.	Thermodynamic equilibrium with two examples **Thermodynamic equilibrium**, condition or state of a thermodynamic system, the properties of which do not change with time and that can be changed to another condition only at the expense of effects on other systems.. For a thermodynamic equilibrium, Mechanical equilibrium, Electrical equilibrium, Chemical equilibrium, and thermal equilibrium need to be satisfied. It is a state of a physical system in which it is in mechanical, chemical, and thermal equilibrium and in which there is therefore no tendency for spontaneous change. For example, a cup of water sitting on your desk, defined by the center 50% of its volume is very likely in thermal equilibrium. Deep ocean water is typically in thermal equilibrium with its surroundings, barring thermal vents or strong ocean currents. Motorcycle engine must be at very high temperature while running. After we stop it, it is cooled by the surrounding air which is cooler as compared to the engine temperature. After some time engine reaches the surrounding air temperature. This condition is said to be thermal equilibrium. The moment when the temperature of the engine reaches the surrounding air temperature, it is said to be at thermal equilibrium.	**02 mark** **02 mark**

	ii)	**Use equation of state to find density of air when atmospheric conditions are 760 mm of Hg and 30°C. Take R = 287 J/kg K.**	
	Sol.	Using the equation of state 760 mm of Hg = 1 bar = 100 KPa ; Take R= 287 J/ KgK = 0.287 KJ/KgK PV = mRT 100 V = m x 0.287 (30+273) m/V = 1.15 kg/m3 = Density of air	**02 marks** **02 marks**
	iii)	**Represent generation of steam on H-S diagram. Show constant dryness fraction lines, constant temperature lines, saturated line and superheated region on the same.**	
	Sol.	Typical Mollier Enthalpy - Entropy Diagram  	**02 marks** **02 marks**
Q.2.		**Attempt any FOUR of the following:**	**16 Marks**
	a)	**Write continuity equation for nozzles. State involved with their units. meaning of all terms**	
	Sol.	Continuity equation for nozzle Mass flow rate = Density x Area x Velocity (Density = 1/v) m = (AC/v) = A_1C_1/v_1) = (A_2C_2/v_2) where, m = mass flow rate of steam in kg/s A= cross sectional area of nozzle at given section in m^2 v = specific volume of steam at given section in m^3/kg	**02 marks** **02 marks**

		C= velocity of steam in m/s	
	b)	**In surface condensers write role of** (i) **Water tubes** (ii) **Shell** (iii) **Baffle plate** (iv) **Tube sheet**	
	Sol.	Function of parts in surface condensers 1. Water tubes- Cooling water flows through it , for convective heat transfer to occur with steam outside the tubes 2. Shell- Outer body, all components are enclosed in it 3. Baffle plate- baffles provide support to tubes and also deflect the fluid flow approximately normal to tubes. This increases turbulence of shell side fluid and improves heat transfer 4. Tube sheet- All tubes are supported at the end in tube sheet	**01 mark each**
	c)	**A typical application has wall made up of two different materials with inner layer 20 mm thick and outer layer 3 mm thick. The temperature difference across wall is 35°C. Thermal conductivity of inner layer material is 0.1 W/m K and outer layer material is 20 W 1m K. How much heat will transfer per m2 of the wall will take place across the wall.**	
	Sol.	Rate of heat transfer per m^2 $Q/A = (T_1-T_2) / [(L_1/K_1) +(L_2/K_2)]$ $= 35/[(0.02/0.1)+(0.003/20)]$ $=174.86 W/m^2$	**02 mark** **02 mark**
	d)	**State two similarities and two dissimilarities between heat and work.**	
	Sol.	Heat and work Similarities- Both are not properties of system, both are boundary phenomena, both are path functions, both are form of energy Dissimilarities-Work is high grade energy, heat is low grade energy ; Entire heat cannot be converted into work, but entire work can be converted into heat ; System can possess heat, but it never possess work	**02 marks** **02 marks**
	e)	**Differentiate between isothermal and isentropic processes(any four points)**	
	Sol.	Isothermal Vs Isentropic (Any 4 points)	**01 mark each**

Isothermal process	**Isentropic Process**
Temp remains constant	Entropy remains constant
Piston displacement required is very slow, quasi static process	Piston displacement required is very fast.
To carry out the process, thermal reservoir	To carry out the process, perfect thermal insulation is required, no heat transfer

is required	should take place	
Law is PV = Constant	Law is PV^{Υ}=Constant	
$dQ = dW = P_1V_1\log_e(V_2/V_1)$	$dQ = 0$; $dW = (P_1V_1 - P_2V_2)/\Upsilon-1$	

	f)	**In a constant pressure process steam is generated from 10 bar and 0.8 dry condition till it become dry and saturated. Determine amount of heat added per kg of steam. From steam table at 10 bar Tsat = 179.9°C hf = 762.6 kl/kg, hg = 2776.2 kJ/kg**	
	Sol.	Constant pressure process Final condition of steam is dry saturated Enthalpy of dry steam = hg= hf + hfg =2776.2 KJ/Kg ….Given Latent heat of vaporization = hfg = hg – hf =2776.2-762.6 =2013.6 KJ/Kg Initial condition of steam is 0.8 dry Enthalpy of wet steam = hw= hf + x. hfg = 762.6+0.8 X 2013.6 =2373.48 KJ/Kg Heat added = hg-hw = 402.72 KJ/kg	**02 mark** **02 mark**
Q.3.		**Attempt any <u>FOUR</u> of the following:**	**16 Marks**
	a)	**With neat sketch describe working of reaction turbine.**	

Sol.

Working principle of reaction turbine-

-A turbine in which steam pressure decreases gradually while expanding through the moving as well as through the fixed blade is known as reaction turbine. **2 Marks**

-In pure reaction turbine , the drop of pressure with expansion and generation of kinetic energy take place in moving blades the steam jet leaves the moving blades at greater velocity than that they enter blades.

-The jet of steam leaving the moving blade with greater velocity reacts on the blades and turn them round. The passage through moving blade of reaction turbine is made convergent so the steam expand as is passes through moving blades.

-The expansion causes the steam to leave the moving blade as higher velocity than as which it entered.

2 Marks

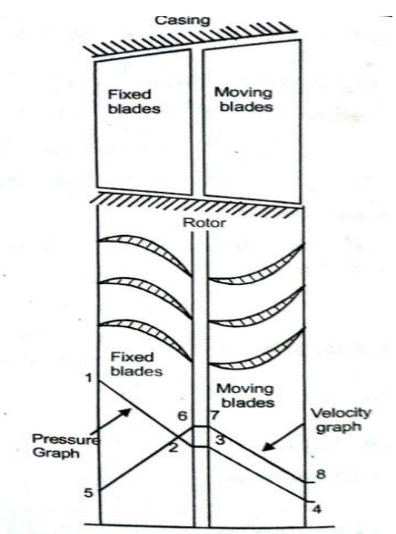
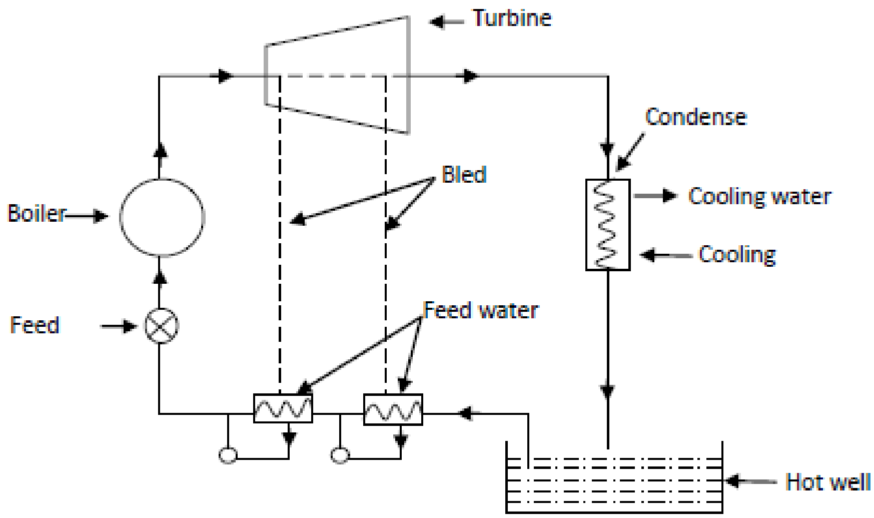
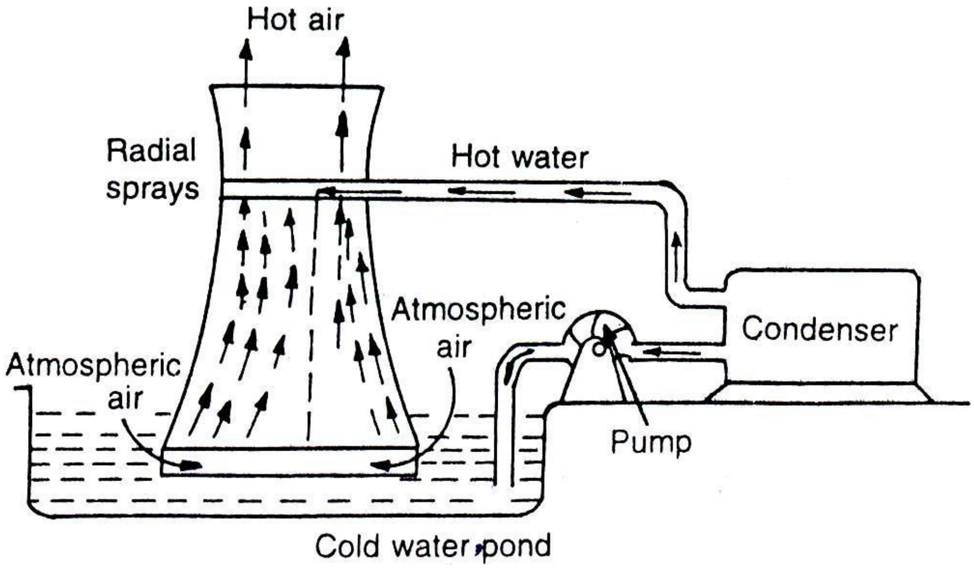


Figure: Reaction turbine

	b)	**Find condenser efficiency when following readings were obtained on a steam surface condenser.** **(i) Atmospheric pressure = 760 mm of Hg** **(ii) Vacuum in condenser = 690 mm of Hg** **(iii) Cooling water inlet temperature = 28°C** **(iv) Cooling water outlet temperature = 39°C**	
Sol.		**Condenser Efficiency** h_v = 690 mm of Hg; h_b= 760 mm of Hg ; T_{wo} = 39 ^{0}C ; T_{wi} = 28^0 C Pressure in condenser $P_c = h_b - h_v$ = 760- 690 = 70 mm of Hg = [(70/760) x 1.01325] = 0.0933 bar At 0.0933 bar condenser pressure, saturation temperature T_s = 45^{0}C Condenser efficiency = (T_{wo} - T_{wi})/ (Ts - T_{wi}) = (39-28)/ (45-28) = 0.647 **Condenser efficiency = 64.7%**	**2 Marks** **2Marks**
	c)	**State Fourier's law of 'conduction and Stefan Boltzmann law of radiation. Express mathematically.**	
Sol.		**Fourier law of heat conduction-** It state that 'for homogeneous material, the rate heat transfer in steady state in any direction is linearly proportional to temperature gradient in that direction. Q α dt/dx Q =-k dt/dx **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. E α T^4 E= σT^4	**1 Marks** **1 Marks** **1 Marks** **1 Marks**
	d)	**State first law of thermodynamics for** **(i) closed system and cyclic process** **(ii) closed system and non-cyclic process**	
Sol.		**First Law of Thermodynamics:** **i) Closed System Cyclic Process :-** 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. According to this statement of first law the potential energy can be converted into kinetic energy and kinetic energy can be converted into potential energy but in natural practice this does not happen. **ii) Closed system Non cyclic process:-** 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 = ΔU + W	**2 Marks** **2 Marks**
	e)	**Air is heated at constant volume from initial condition of 1 bar and 30°C**	

		to 5 bar. **Calculate** **(i) Final Temperature** **(ii) Work done** **(iii) Change in Enthalpy.** **Take for air R = 287 J/kg ^{0}K, Cp = 1.005 kJ/kg^{0}K**	
Sol.		Given: Constant volume process So, $V_1=V_2$ P_1=1 bar $T_1=30^0C=273+30=303K$ P_2=5 bar C_p=1.005 kJ/Kg^{0}K R= 287 J/Kg^{0}K=0.287 kJ/Kg^{0}K Calculate; Final Temp T_2=? Work done=? Change in enthalpy Δh=? We Know that at constant volume process; $P_1/P_2=T_1/T_2$ T_2=(P2/P1)*T1 **T_2**=(5/1)*303 **T_2 =1515^{0}K** At Constant volume process **Work done= 0** Change in enthalpy $\Delta h= m\, C_P\, \Delta T$ =1 X 1.005 X (1515-303) Change in Enthalpy=**Δh =1218.06 kJ/Kg**	**02 marks** **01 marks** **01 marks** **01 marks** **01 marks**
	f)	**State regulations for boilers which fall under IBR boiler. (Any four)**	
Sol.		**Boiler Regulations : (Any 4 Points)** 1. A boiler cannot be put to use unless it has been registered with the Chief Inspector of	

	Boilers. 2. The maximum working pressure of the boiler has to be determined by Boiler Inspector who will issue certificate for this. Owner cannot exceed this pressure limit in any case. 3. In case of accident, it should be reported by owner within 24 hours with full details. 4. The rules, regulations and bye-laws governing the upkeep and maintenance of boilers, procedure of registration, inspection and certification of maximum pressure, safety conditions etc. are subject to a revision by a Central Board under control of Govt. of India. 5. The boiler house plan, chimney design (Max height 30.48 m from floor) should be approved by boiler inspector. 6. Owner should apply for registration in prescribed format, inspector should fix date of inspection within 30 days, conduct inspection/examination of boiler, Issue the certificate of registration not exceeding 12 months period. 7. Following inspections are carried out by Boiler Inspector at various stages/ levels /need- Inspection for registration, Hydraulic test, steam test, annual inspection, Inspection under steam, Internal inspection, Accident inspection, Casual inspection 8. Violation of law is liable to prosecution and punishment with fine.	**1 mark for each Point (any 4)**
Q.4.	**Attempt any FOUR of the following:**	**16 Marks**
a)	**Draw a neat sketch of regenerative feed heating.**	
Sol.	**Regenerative Feed Heating** 	**4 Marks**
b)	**Describe with neat sketch working of natural draft cooling towers.**	
Sol.	**Natural draft cooling tower:** -In natural draught cooling tower, the circulation of air is produced by the pressure difference of air inside the tower and outside atmospheric air Hot cooling water falls down in a form of sprays and atmospheric air enters from bottom of the tower. -The falling water gives up its heat to the rising column of air and temperature of circulating water reduces -In natural draught cooling tower, hot water is pumped to ring troughs. 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).	**2 Marks** **2 Marks**



c) **Describe only construction and working of pipe in pipe heat exchanger. State it's two applications.**

Sol.

Pipe Heat Exchanger:

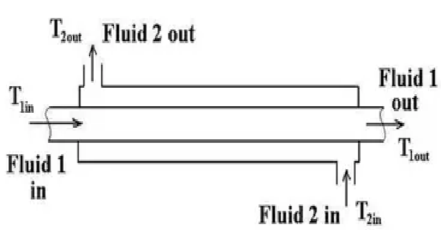
Construction and Working :

In Pipe heat exchanger design, an important factor is the type of flow pattern in the heat exchanger. A pipe heat exchanger will typically be either counter flow , parallel flow or Cross flow pipe heat exchanger. **2 Marks**

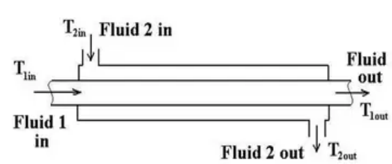
A pipe heat exchanger, in its simplest form is just one pipe inside another larger pipe. One fluid flows through the inside pipe and the other flows through the annulus between the two pipes. The wall of the inner pipe is the heat transfer surface. The pipes are usually doubled back multiple times as shown in the diagram at the left, in order to make the overall unit more compact.

Application : Oil refinery industries , Waste water management, Refrigeration system **1 Mark**

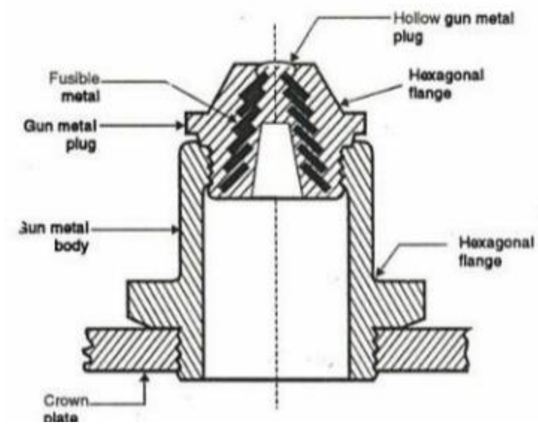
Counter Flow



Parallel Flow



d)	**Compare performance of refrigerator and heat pump when both are operating between 9°C and 35°C. Assume both are working on reversible Carnot cycle.**	
Sol.	Given; $T_L=9^0C= 9 + 273=282\ ^0K$ $T_H=9^0C= 35 + 273=308\ ^0K$	**02 marks**
	For refrigerator; COP(refrigerator) = $T_L/(T_H - T_L)$ =282/(308-282) COP(refrigerator) =10.8461 COP(heat pump) = $T_H/(T_H - T_L)$ =308/(308-282) COP(heat pump)=11.8461	**02 marks**
	There for, COP(heat pump)=1 + COP(refrigerator) From above result COP of Heat pump is gretter than COP of refrigerator.	
e)	**Describe anyone safety mounting used in boilers with sketch.**	
Sol.	Boiler Mounting : **Fusible Plug** **Function:** It is very important safety device of a steam boiler, which protects the fire tube boiler against overheating.	**1 Marks**
	Location: It is located just above the furnace in the boiler. It consists of gun metal plug fixed in a gun metal body with fusible molten metal.	**1 Marks**
	Construction: It is fitted on the fire box brown plate or over the combustion chamber. The fusible plug consists of two hollow guns and one conical plug shown as figure. A hollow gun metal body is screwed to the fire box crown plate of boiler. Another hollow gun metal is screwed to the first body. Third plug is made from copper is locked with the second plug by pouring metal in to the grooves provided on the both plugs.	**1 Marks**
		1 Marks



Working Principle:

In normal working condition, the upper surface of fusible plug is covered with water which keeps the temperature of the plug below its melting point while other end of plug is exposed to fire or hot gases. The low melting point (tin or lead) does not melt till the upper surface of plug is submerged in water. But in case of water level in boiler falls below the danger levels, the fusible plug uncovered by the water and get exposed to steam. This overheats the plug and the fusible metal having low melting point which melts quickly. Thus the third plug drops down and second hollow gun became open, the steam rushes into the furnace and puts out the fire (stop).

	f)	**Describe four losses in steam turbines in 1/ 2 sentences each.**	**04 Marks**
	Sol.	**Energy losses in steam turbines [Any four points with explanation 01 mark each]** (i) **Residual velocity loss**- The steam leaves the turbine with a certain absolute velocity which results in loss of KE. This loss is about 10 to 12% .It can be reduced by multistaging. (ii) **Losses in regulating valves**-Due to throttling action in valve , steam pressure drop occurs. Hence steam pressure at entry to turbine is less than the boiler pressure. (iii) **Losses due to friction in nozzle**-Friction occurs both in nozzle and turbine blades. In nozzle, nozzle efficiency is considered, whereas in turbines, blade velocity coefficient is taken into account. This loss is about 10% (iv) **Loss due to leakage**-The leakage occurs between the shaft, bearings and stationary diaphragms carrying the nozzles in case of impulse turbines. In reaction turbine the leakage occurs at blade tips. This is about 1-2%. (v) **Loss due to mechanical friction**-This occurs in bearings and may be reduced by lubrication (vi) **Loss due to wetness of steam**-In multistage turbine, condensation occurs at last stage ,so in dragging water particles with steam, some KE of stem is lost (vii) **Radiation loss**-As turbines are heavily insulated to reduce the heat loss to surroundings by radiation and so these losses are negligible	**1 Mark for each point (any 4)**
Q.5.		**Attempt any TWO of the following:**	**16 Marks**
	a)	**Describe any two sources of air leak in surface condenser. Also describe effect of air leak on latent heat of steam and cooling water requirements.**	
	Sol.	✓ **The main sources of air leakage 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	**02 marks**

		feed water. 3) In jet condensers, a little quantity of air accompanies the injection water. ✓ **Effects of Air Leakage in Condenser** 1) The performance of condenser is affected by air leakage: 2) The increased amount of air in the condenser, the condenser pressure or back pressure is increased; this reduces the useful work done in the prime mover. 3) Presence of air also lowers the partial pressure of steam which decreases the saturation temperature of steam and hence evaporation enthalpy of steam increases therefore more amount of cooling water required in the condenser.	**02 marks**
	b)	**Differentiate induced draft and forced draft cooling towers based on** **(i) Location of fan** **(ii) Corrosion of blades** **(iii) Efficiency** **(iv) Fan size**	
	Sol.	(see table below)	**01mark each**

Sr. No.	Particular	Forced Draft	Induced Draft
i.	**Location of fan**	The fan is located at the base of the tower.	Mounted at the top of the tower.
ii.	**Corrosion of blades**	As it handles dry air, problem of fan blade erosion is avoided.	As it handles wet air, proble of fan blade erosion is not avoided.
iii.	**Efficiency**	It is more efficient.	It is not efficient.
iv.	**Fan size**	The fan size is limited to 4 meters.	The fan size of 20 m in diameter can be used of fan.

c) **A typical shape when perfect black emits 150 W/m2 energy by radiation. How much energy will it radiate when it is not perfectly black and have emissivity of 0.8.**

Sol. **Data:**

Emissive power of black body= E_b=150 W/m^2

Emissive power of non black body=E=?

Emissivity =ε=0.8

There for,

$$\varepsilon = E/E_b$$

$$E = 0.8 \times 150$$

$$= 120 \text{ W/m}^2$$

When body is not perfectly black it will radiate 120 W/m^2 energy.

d) **An engine is supplied with 4 kW of heat energy. It is found that it produce 4 kW of work. Which kind of perpetual machine it is? Which law is violated? Also describe other kind of perpetual machine you know.**

PMM-II: — **02 marks**

A heat engine which violates Kelvin plank statement of the second law of thermodynamics is known as Perpetual Motion Machine of the second kind (PMM-II). Or 100 percent efficient machine which is impossible to obtain in actual practice, because no machine can convert whole of the heat energy supplied to it into its equivalent amount of work.

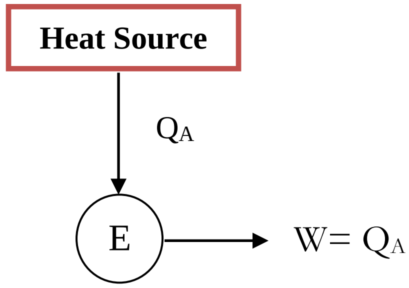


Fig. PMM-II

02 marks

PMM-I:
A heat engine which violets the first law of thermodynamics, such machine is known as Perpetual Motion Machine of first kind (PMM-I).

Or

It is defined as a machine which produces work energy without consuming an equivalent of energy from other source. Such a machine is impossible to obtain in actual practice, because no machine can produce energy of its own without consuming any other form of energy.

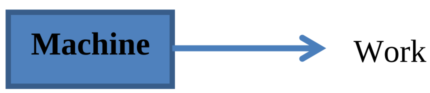
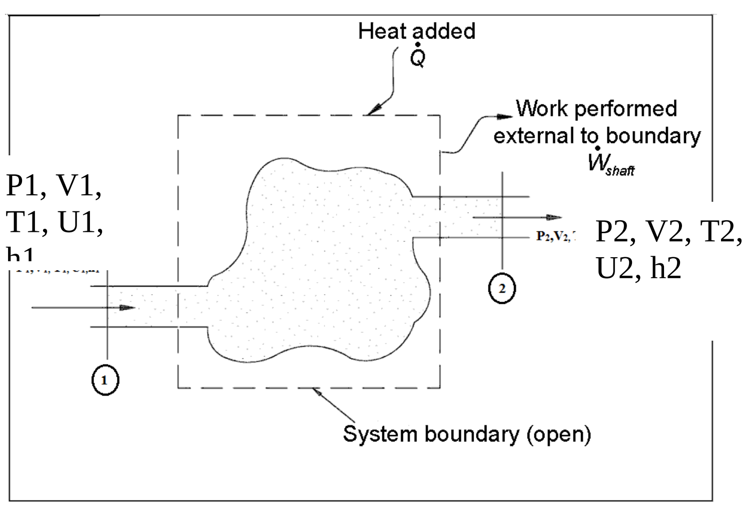


Fig. PMM-I

e) **Write steady flow energy equation considering mass flow rate of fluid. Write units of different quantities involved.**

Steady flow process (open system) :



Hence steady flow equation can be expressed as:

Internal Energy at 1 + Potential Energy at 1 + Kinetic Energy at 1 + Flow work at 1 + Heat supplied **=** Internal Energy at 2 + Potential Energy at 2 + Kinetic Energy at 2 + Flow work at 2 + Work done

02 marks

i.e.

Hence the steady flow energy equation is,

$$h_1 + \frac{c_1^2}{2} + Z_1 g + Q = h_2 + \frac{c_2^2}{2} + Z_2 g + W$$

Where,

02 marks

h_1 & h_2 = Enthalpy at inlet and outlet in---- $\frac{J}{Kg}$

C_1 & C_2 = velocity at inlet and out of fluid---- $\frac{m}{s}$

Z_1 and Z_2 = height of inlet & outlet above datum-------**m**

Q = heat supplied per ---------------**Joule**

W = work done by 1 kg of fluid----**Joule**

PV = Flow work---------**N-m or Joule**

f) **An ideal gas is heated at constant volume and then expanded isothermally. Show processes on P-V & T-S diagrams.**

Sol.

02 mark P-V

02 mark T-S

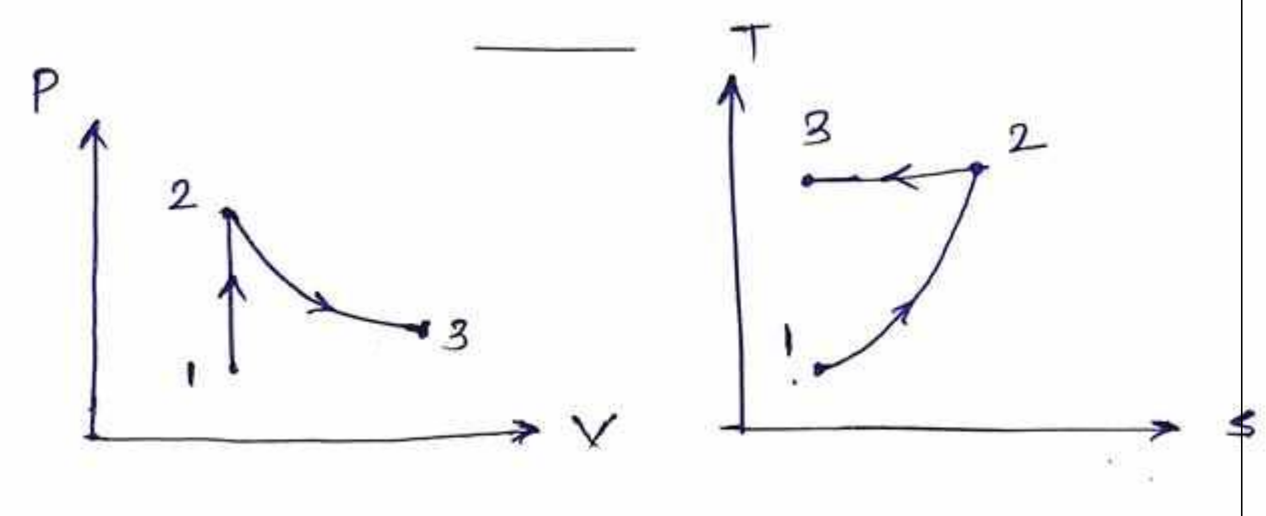
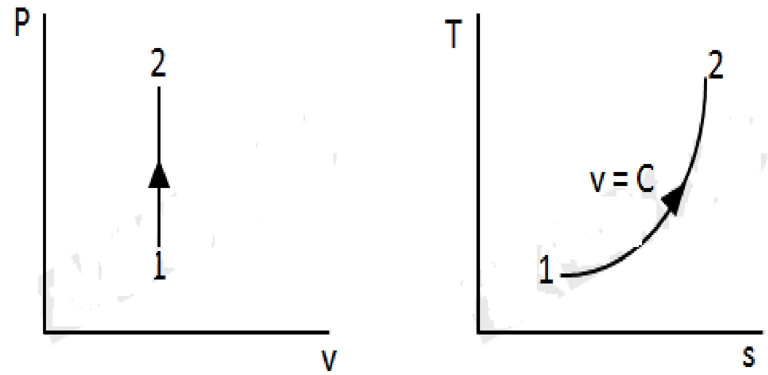
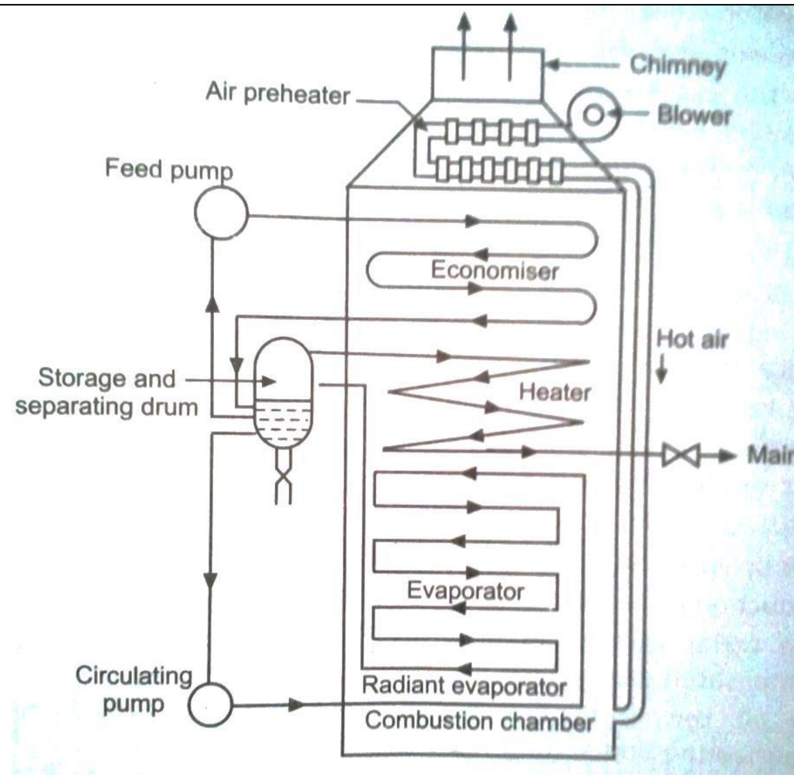
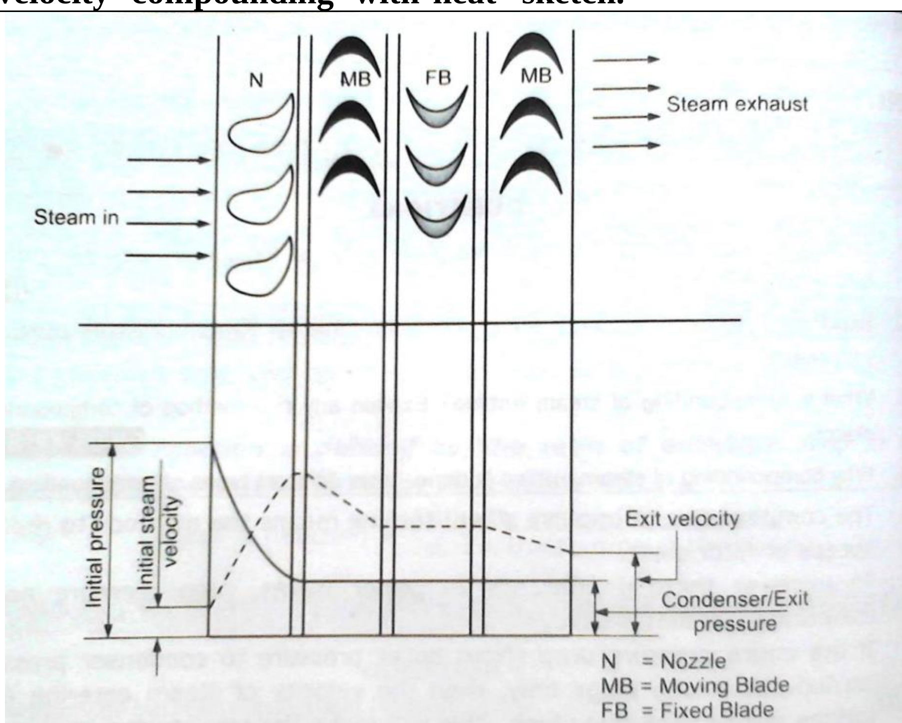
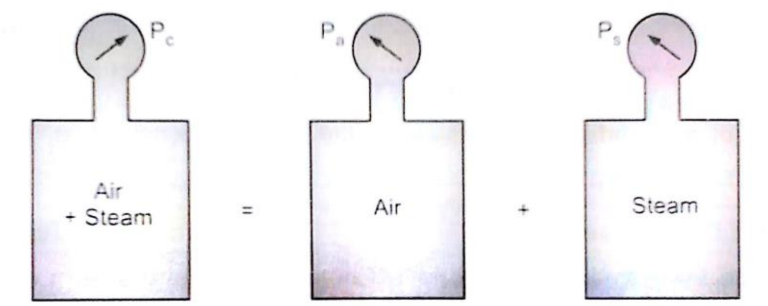


Figure: Constant volume and isothermal process

Process 1-2 : Constant volume process
Process 2-3 : Constant temperature process (Isothermal process)

Q.6.		**Attempt any FOUR of the following:**	
	a)	**Represent constant volume process on PV & TS diagram for steam.**	
	Sol.	 **Figure: Constant volume process**	**02 mark P-V** **02 mark T-S**
	b)	**Draw Lamont Boiler. Label the components and discuss the working and construction.**	
	Sol.	 **Figure: Lamont boiler** 1. This is a modern high pressure, water tube boiler working on a forced circulation. 2. The circulation is maintained by a centrifugal pump, driven by a steam turbine, using steam from the boiler. 3. Feed water is supplied to economiser from hot well which is passed to separating and storing drum. 4. Water from separating and storing drum, flows by gravity to circulating pump. 5. Circulating pump circulates the water to set of tubes known as convective evaporator and then radiant evaporator. 6. By the time, water leaves the radiant evaporator, it converts into steam. 7. This steam is passed through storage and separator drum. 8. From separator and storage drum steam is fed to super heater to superheat.	**02 marks For fig.** **02 marks for explanation**

		9. The superheated steam is passed to main steam to supply for required application. Lamont boilers generates 45 to 50 tones steam per hour at 130 bar with 500^0 C.	
	c)	**State necessity of super heater in steam boilers. State advantages of economizer. (two each)**	
	Sol.	**Necessity of super heater in steam boilers:** 1. The efficiency of the boiler is increase with the use of superheated steam. 2. It eliminates the erosion of the turbine blades. 3. It reduces specific steam consumption of engine and turbine. **Advantages of economiser:** 1. Saving of fuel. 2. Dissolved gases as air and CO_2 are removed by preheating the feed water; so reducing corrosion and pitting. 3. There will be less temp. strain in the boiler plates as the feed water enters the boiler at a higher temp. 4. Circulation of the water is very well maintained as quick evaporation is possible because of hot feed water. **5.** This unit improves the overall efficiency of the boiler by reducing the fuel consumption.	**02 marks** **02 marks**
	d)	**Describe velocity compounding with neat sketch.**	
	Sol.	 **Figure: Velocity Compounding** **ii) Velocity Compounding:** ✓ In velocity compounding arrangement of blades and nozzles are made as below; N-M-F-M Where; N = Nozzle M = Moving blade F =Fixed blade	**Figure** **02 mark** **02 mark for explanation**

		✓ 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.	
	e)	**Explain Dalton's law in respect to steam condensers.**	
	Sol.	It states that' "The pressure exerted by mixture of air and steam is equal to sum of partial pressures, which each constitute would exert, if it occupies the same volume".  Figure: Dalton's law of partial pressure Mathematically, $P_c = P_a + P_s$ Where; P_c = Pressure in condenser containing mixture of air and steam P_a = Partial pressure of air P_s = Partial pressure of steam	**Statement 2 marks** **Mathmatical expression 2 marks**
	f)	**Define heat exchanger. Classify heat exchangers based on geometry, direction of fluids, method of heat exchange.**	
Sol.		1. A heat exchanger is a device, which transfers thermal energy between two fluids at different temperatures. 2. In most common engineering applications, both fluids are in motion and the main mode of transferring heat is convection. Heat exchanger can be classified based on: 1. According to the geometry: i. Tubular ii. Plate iii. Plate fin iv. Tube fin 2. According to the direction of fluid: i. Parallel flow ii. Counter flow iii. Cross flow 3.According to the method of heat exchange: i. Single phased free or forced convection ii. Boiling or condensation iii. Radiation or combined convection radiation	**Definition 1 Mark** **Classification 3 Marks**