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- a) Attempt any Six **Marks**

i) First law of thermodynamics.

First law for cyclic process : It states that whenever a system under goes a cyclic change, the algebraic sum of work transfer is proportional to algebraic sum of heat transfer. 1 Marks

$$\phi dw = J\phi dQ$$

b) First law for closed cycle for non cyclic process: it states that if system under goes a process during with both heat transfer and work transfer involved, the net energy transferred will be stored within the system 1 Marks

$Q - W = \Delta\varphi$ where Q =A heat transfer

W = work transfer

$\Delta\varphi$= change in internal energy.

ii) Thermodynamic work - Work is said to done by a system, it a sole effect on things external to the system can be reduced to the raising of weight. 1 Marks

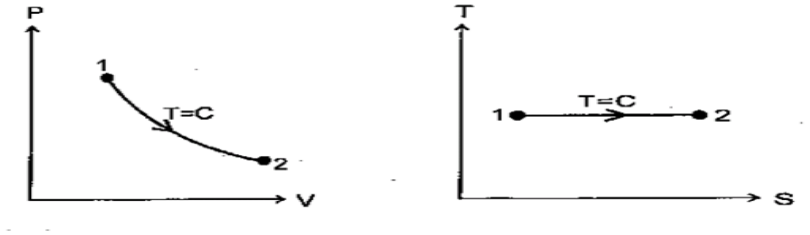
SI unit N- m or Joule

iii) Charles Law – It state that '' the volume of given mass of gas varies directly as its absolute temperature when the absolute pressure remains constants .

$V \propto T$ P *is constant*

iv) Isothermal process.

iii) Isothermal or constant temperature process (T = C) or n = 1



v) I) Degree of superheat – It is difference between the temperature of Superheated vapour and the saturation temperature correspondingly to given pressure is said to be Degree of Superheat.

1+1 Marks

II) Latent heat of steam (LH) – A heat required to vaporized the liquid to vapor at constant temperature without change in temperature is known as Latent heat of steam.

vi) Bleeding of a seam – The process of draining steam from the turbine at a certain point during its expansion & using these steam for heating the feed water supplied to boiler is known as Bleeding of steam . 02 Marks

vii) Mach number is defined as the Square root of the ratio the inertia of fluid force to elastic force. 1+1 Marks

$$\text{Mach number} = \sqrt{\frac{inerta\ force}{elastic\ force}}$$

OR

Mach Number is defined as velocity at a point in a fluid to velocity of sound at that point at given instant of time

$M = \frac{V}{C}$ Where V = velocity of fluid

C = velocity of Sound

Significance of Mach Number – It match number is less than one, flow is Subsonic & nozzle is Convergent. If Mach Number is equal to one, flow is sonic, If Mach number is greater than one, flow is Supersonic & nozzle is divergent.

viii) Sources of air leakages in condenser-

1. Feed water to boiler contains some amount of dissolved air in it , this air goes in the condenser with exhaust steam. 2 Marks
2. The pressure inside the condenser is less than atmosphere so the out side air leaks through joints, packing and glands in to the condenser.

3. In jet condenser, dissolved air with cooling water enters the condensers and it gets separated at Low pressure in the condensers.

Q.1- b) Attempt any Two **2+2 Marks**

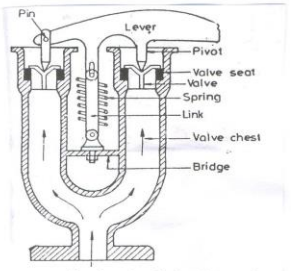
i) List of boiler mounting.

A.Safety Valves. B. Fusible Plug.

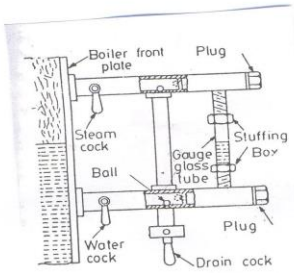
C.Water level indicator. D. Combined high steam & Low water safety valve.

E. Pressure Gauge F. Blow off cock

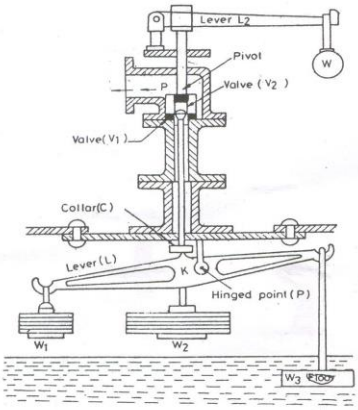
(Any one of the following)



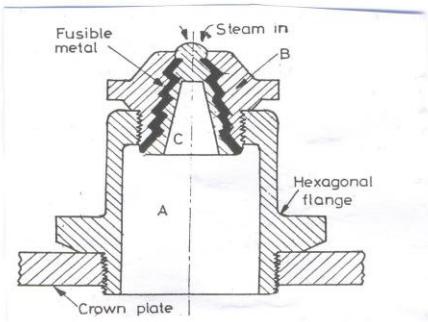
Spring loaded safety valve



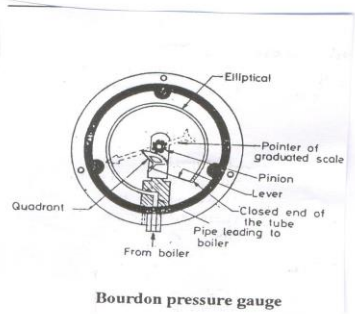
Water level indicator



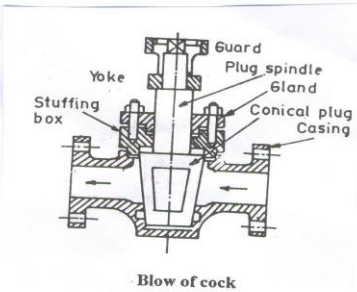
High steam and low water safty valve



Fusible plug



Bourdon pressure gauge



Blow of cock

ii) Dalton Law of partial pressure & equation. 2+2 marks

This Law state that- " the total pressure exerted by a mixture of air and water vapor on the walls of its container is the Sum of partial pressure exerted by air separately and that exerted by vapour separately at the common temperature of condenser .

P = Pa + Ps

Where Pa = partial pressure exhausted by air

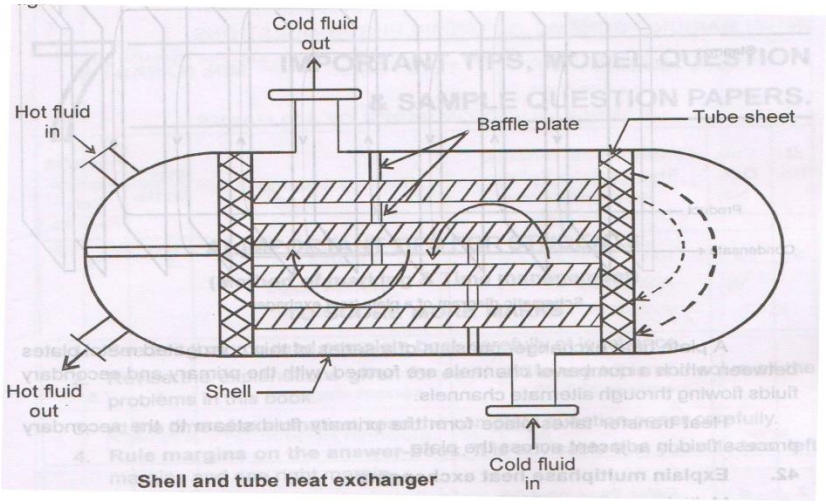
ps= partial pressure exhausted by vapor

P = total pressure of mixture at temperature.

Applications: 1)Condenser

iii) Working of Shell and tube type of heat exchanger. 02 Marks

(Two marks for sketch and two for explaination)



Shell and tube heat exchanger

It consist of bundle of round tube placed inside Cylindrical shell with tube axis parallel to that of shell. One fluid is carried through a bundle of tubes enclosed by shell. The other fluid forced through shell and flow over the outside surfaces of tube.

Q.2 Attempt any Four

a) Steady how energy equation per unit mass

$$q + h_1 + gZ_1 + \frac{1}{2}C^2 = w + h_2 + gZ_2 + \frac{1}{2}C_2{}^2$$

where q = heat Supplied in KJ or J

h_1= enthalpy of substance entering in to system.

h_2= enthalpy of substance leaving from system.

$PE_1 \& PE_2$ = potential energy.

$KE_1 \& KE_2$ = kinetic energy.

$Z_1 \& Z_2$= height from datum

$C_1 \& C_2$ = Velocity

W = Work performed.

i) Nozzle – The passage of varying cross sectional area in which heat energy is converted in to kinetic energy.

Applying SFEE

$$q + h_1 + 9Z_1 + \frac{1}{2}C^2 = w + h_2 + 9Z_2 + \frac{1}{2}C_2{}^2$$

where $q = 0,\ Z_1 = Z_2$

C_1 & C_2 Velocity at inlet& outlet

$W = 0$

$$O + h_1 + 0 + \frac{1}{2}C_1^2 = h_2 + \frac{1}{2}C_2{}^2$$

$$h_1 - h_2 = \frac{1}{2}C_2{}^2 - C_1^2$$

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

OR

If C_1 is less as compare C_2

C_1 = neglected

$$C_2 = \sqrt{2(h_1 - h_2)}$$

ii) Steam Condenser :- It is a device to condenser the exhaust steam
Heat- is lost $q\ is - ve$ by applying SFEE

$$q + h_1 + gZ_1 + \frac{1}{2}c_1^2 = w + h_2 + gZ + \frac{1}{2}C_2{}^2$$

$$-q + h_1 + 0 + 0 = 0 + h_2 + 0 + 0$$

$$q = h_1 - h_2$$

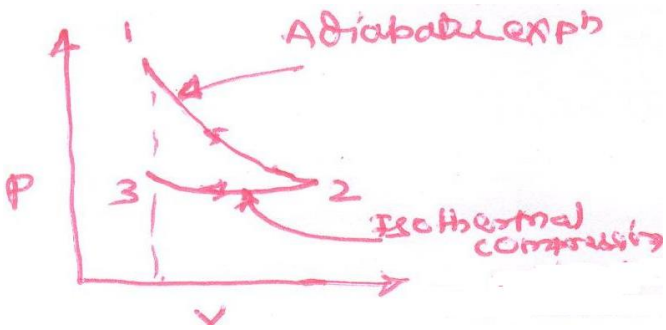
(marks 2+1+1)

b) Given data $V_1 = 0.340 m^3$, $P_1 = 8\ bar$, $C_p = 0.950\ kj/$kg

$T_1 = 130^0 + 273 = 403k$, $C_v = 0.710\ kj/$kg

$P_2 = 5\ bar$

Isothermal process $v_3 = v_1 = 0.340\ m^3$



For adiabatic expansion (1-2)

$$r = \frac{CP}{CV} = \frac{0.950}{C0.710} = 1.338$$

for process 1-2

$$P_1 v_1^r = P_2 v_2^r$$

$$\frac{P1}{P2} = (\frac{v_2}{v_1})^r, = \left(\frac{p_1}{p_2}\right) 1/_r = \frac{v_2}{v_1}$$

$$(\frac{8}{5})^{1/338} \mathbf{X0.340} = v_2$$

$$v_2 = (1.6)^{0.7} x\ 0.340$$

$$= 1.3895x0.340$$

$$v_2 = 0.472 m^3$$ 02 Marks

process 1-2 (Isothermal process)

$$\frac{T_2}{T_1} = (\frac{P2}{P1}) \frac{r-1}{r}$$

$$T_2 = 403 \left(\frac{5}{8}\right) \frac{1.338-1}{1.338}$$

$$= 403(0.625)^{0.2526}$$

$$T_2 = 358. K = T_3 = \text{Isothermal process}$$

For process 2-3 Isothermal process

$$P_2 V_2 = P_3 V_3 =$$

$$P_3 = \frac{P_2 V_2}{V_3} = \frac{5x0.472}{0.340}$$

$$P_3 = 6.94 bar$$ 02 Marks.

c) Classification of steam boilers on basis of 04 Marks

i) According to use

a) Stationary b) portable C) Marine D) Loco motive

ii) Location of furnace

d) Externally fired e) Internally fired

iii) Axis of shell

a) Vertical b) Horizontal

iv) Fuel Used

a) Coal b) Oil

d)(Any six) 04 marks

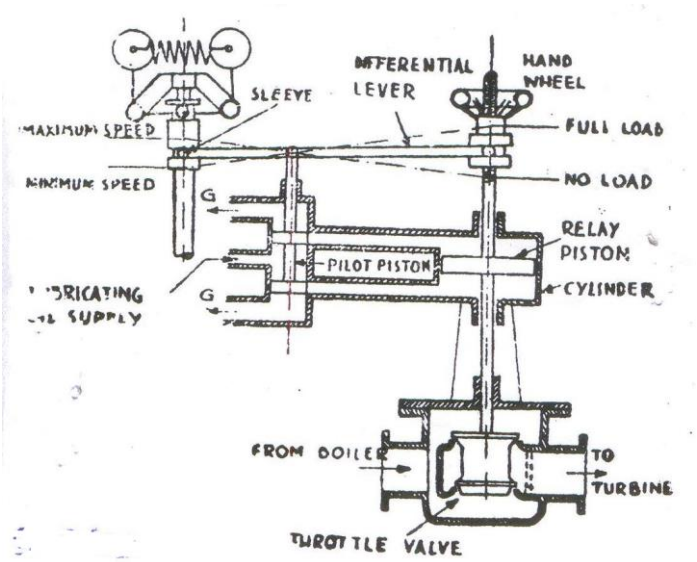
Impulse turbine	Reaction Turbine
i) Complete expansion of steam take place in the nozzle	i) Expansion of steam take place partly in fixed blade & partly in moving blades.
ii) This pressure remain constant when the steam passes over rotors blade	ii) This drop take place in moving as well as fixed blade.
iii) It friction is neglected the relative velocity of steam passing over rotor blade remains constant	iii) Its friction is neglected the relative velocity & steam passing over rotor blade increase because of expansion in rotor blades.
iv) Area of flow of rotor blade remains constant	iv) The area of flow of rotor blades changes like that of nozzles along the blades passage
v) At Low load the efficiency is low.	v) As Low load the efficiency is high.
vi) Less numbers of states required	vi) More no of blades are required.
vii) Occupies less space per unit power.	vii) Occupies more space per unit power.
viii) Suitable for Small power.	viii) Suitable for medium & high power.

e) Throttle governing of steam turbine – (02 marks for sketch and 02 for explanation)

In throttle governing the pressure of steam is reduced before reaching the turbine at part loads, the flow of steam entering in to the turbine is restricted by a balanced throttle valve which is controlled by the centrifugal governor. The governor may be arranged to actuate the throttle valve directly. This throttle valve is actuated by the relay piston sliding in the cylinder, as floating or differential lever is attached at one end of governor sleeves and other end to throttle valve spindle & at governor sleeves and other end to throttle valve spindle and at intermediate points to a pilot or piston valve which consist of two small piston valve covering the port without any lap.

Operation- Let us assume that turbine is running at a load less than full load. the throttle valve will be Opened so such extent that the steam flow is just sufficient to maintain constant speed under given load condition.

Load on this turbine is reduced rotation quickly there is now an excess of energy being supplied to the turbine and the surplus will accurate the rotor. the turbine and governor speed will rise and this cause a lift of governor sleeves & supplying steam to turbine.



. Diagrammatic arrangement of throttle governing with oil relay.

Q-**3 Attempt any four**

(a) Explain [1 mark for each brief explanation]

(i) **Point Function**-Thermodynamic properties which have got definite value(single value)for given state, they are called as point functions. They are independent of path and depend on only initial and final states .e.g. pressure, volume, temperature

(ii) **Path Function**-Thermodynamic quantities, which are dependent on path followed between two end states of process are called as path functions. e.g. Work, heat

(iii) **State**-It may be identified by observable quantities such as volume, pressure, temp, etc. All such quantities are thermodynamic properties. Minimum two properties are required to define state of a system. Each property has a single value at each state. i.e. all properties are state or point functions.

(iv) **Process**-When a system changes its state from one equilibrium state to another equilibrium state , then the path of successive states, through which, the system has passed, is known as thermodynamic process.

(b) For reversible Adiabatic process, Write equations

(i)Change in internal energy [2 Marks]

$dU = mCv(T2-T1)$ …….with usual notations

(ii) Work done [2 Marks]

$W= mR(T2-T1)/\gamma-1$

$= (P1V1-P2V2)/ \gamma-1$ ….with usual notations

(c) Principle used for forced draught- [2 Marks]

Draught is a difference of pressure which causes a flow of gas in order to maintain continuous flow of fresh air into combustion chamber. Natural draught is dependent on climatic conditions and become less when outside air temp. is high. So artificial draught is created using fan or steam jet.

In forced draught system, a fan or blower is installed near or at the base of boiler grate. The fan delivers air to the furnace under pressure varying from 2.5 cm to about 7.5 cm of water. This is positive draught system because pressure of air throughout the system is above atmospheric pressure.

In induced draught system, the fan is placed near or at the base of chimney. The pressure over the fuel bed is reduced to a level below the atmospheric pressure by fan. By creating partial vacuum in the furnace, the products of combustion are drawn from the main flue and they go up to the chimney.

Advantages of artificial draught:- [2 Marks]

1. High draught requirement can be met (300 mm of water)
2. Draught is independent of climatic conditions
3. No chance of air leakage into furnace as pressure inside furnace is above atmospheric pressure.
4. Easy control of combustion and evaporation
5. Reduced fuel consumption

(d) Necessity of compounding of steam turbines:- [3 Marks]

Generally, in steam power plants, the steam temp and pressure are very high, in order to maintain high thermal efficiency. If in turbine, entire pressure drop from boiler pressure to condenser pressure is carried out in single stage, the velocity of steam entering the turbine becomes very high. This results in very high rotational speed of turbine, which is not useful/ desirable from practical point of view. This may even result in failure of blades due to centrifugal stresses.

To overcome this difficulty, multiple system of rotors is keyed to a common shaft in series and steam pressure or jet velocity is absorbed in stages as it flows over rotor blades. This is known as compounding.

Methods of compounding :- [1 Mark]

1.Pressure compounding.

2. Velocity compounding.

3. Pressure- Velocity compounding.

(e) Function of cooling tower in steam power plant:- [2 Marks]

A majority of large power plants are built adjacent to rivers where cooling water is available in large quantities. but for many plants, source of water is local water supply. in such cases, the same water is circulated over and over again. It must be cooled before it re- enters the condenser tubes. The water is cooled by means of cooling towers.

Thus cooling tower is an artificial device used to cool the hot cooling water coming out of condenser. These are classified as :- [2 Marks]

A] According to type of draught

(a) Natural draught cooling water

(b) Forced draught cooling water

(c) Induced draught cooling water

B] According to material used

(a) Concrete cooling water

(b) Timber cooling water

(c) Steel duct type cooling water

(f) –

(i) Thermal conductivity $K=(Q/A)* dX/dT$ [2 Marks]

It is defined as amount of energy conducted through a body of unit area and unit thickness in unit time when the difference in temperature between the faces carrying the heat flow is $1\ ^0C$. thermal conductivity depends on molecular structure, specific gravity etc .

$K=(Q/A)* dX/dT$

$=(J/s)/m^2 *m/k$

=watts/mK

(ii) Fourier's law of heat conduction : [2 Marks]

For a homogeneous material the rate of heat transfer per unit area in any direction is linearly proportional to temperature gradient in that direction.

$Q/A=dT/dx$

Q/A= -K*dT/dx

Q= -KA*dT/dx

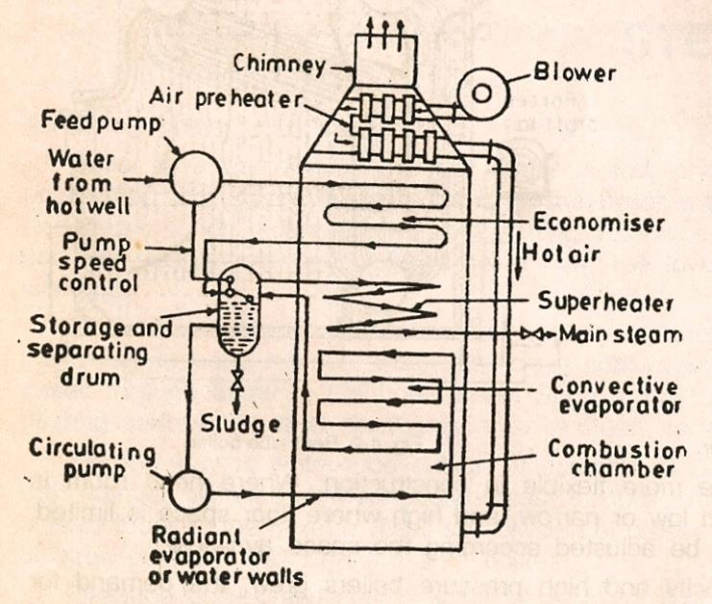
K is constant of proportionality and is called as thermal conductivity. Negative sign indicates that there is decrease in temperature along the direction of heat flow.

Q 4. Attempt any four.

(a)Differentiate [1 mark for each point]

Heat pump	**Refrigerator**
1) it is a thermodynamic system which transfers heat from low temperature body and gives out the same to high temp body.	1) function of refrigerator is to absorb more and more heat from cold body and give it to hot body
2) it works between hot body temp and atmospheric temp	2)It works between cold body temp and atmospheric temp
3) $(COP)_{HP}$ = Q1/Q1-Q2	3)$(COP)_{RF}$ = Q2/Q1-Q2
4) COP of heat pump is greater than COP of refrigerator by unity	4)COP is less
5) in case of HP atmosphere acts as a cold body	5)In case of refrigerator atmosphere acts as a hot body.

(b)Sketch of La-Mont Boiler [2 Marks]



It is a high pressure forced circulation boiler introduced by La-Mont in 1925.It is water tube type and used in Europe and America.

Water is supplied through an economizer to a separating and storage drum which contains a feed regulator that controls the speed of a feed pump. Water from separating and storage drum flows by gravity to circulating pump. Further it goes to convective and radiant evaporator. By the time the water leaves the radiant evaporator, it converts into steam. The steam goes to separating and storage drum and further to superheater for further application.

La-Mont boiler generates 40-50 tones of steam per hour at 130 bar with 500^0 C . This is compact boiler can meet rapid changes in load due to flexibility in design. [2 Marks]

(c)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

(d) Differentiate [1 mark for each point]

Natural (free)convection	**Forced convection**
1)Heat transfer is only due to temp difference	1)Along with temp difference, rate of fluid flow is very imp factor for heat transfer
2)Force causing heat flow is buoyancy force which is proportional to temp difference	2) Force causing heat flow is external force exerted by fan or blower.
3)Heat transfer coefficient is very low.	3)Heat transfer coefficient is very low.
4)Applications are limited because of low heat transfer rate.	4)Used in many engg applications as heat transfer rate is more. E.g. heat exchanger, condenser
5)Bulky equipment are required.	5)Size of equipment is compact.

(e)Data:

Vacuum gauge pressure=hv=714 mm of Hg

Barometric pressure hb=752mm of Hg

Standard barometric reading = 760 mm of Hg

Absolute pressure in condenser,

P=(hb-hv) [1 mark]

Corrected vacuum of Hg in mm = 760-P

=760-(hb-hv) mm of Hg

=760-(752-714)

=722 mm of Hg [2 marks]

= 722 * 1.0135/760 bar

=0.9625 bar [1 mark]

(f) Data:

Pressure of steam = 10 bar

Temp of steam = 195^0 C

But from steam tables, at 10 bar, saturation temp Ts=179.91^0 C

Here, temp of steam is more than saturation temp. Therefore, steam is in super heated temp. [1 mark]

Degree of superheat=195-179.91=15.09^0 C [1 mark]

Volume of superheated steam,

Vsup=(Tsup/Tsat) * Vg

=[(195+273)/(179.91+273)] * 0.19429

Vsup= 0.2007 m3/Kg. [2 marks]

Q. 5 a) (04 marks each)

Although the Kelvin Plank and Clausius statements appears to be different, but they are equivalent (same). The violation of one means the violation of other. This can be proved very easily as follow.

Violation on Kelvin Plank Statement:- Consider the heat pump which violates the Kelvin Plank statement by absorbing heat Q_1 from single reservoir and producing equal amount of work $W = Q_1$. The work delivered by this heat engine is used to drive the heat pump which takes the heat Q_2 from low temperature reservoir and delivers Q_1+Q_2 amount of heat to high temperature reservoir by consuming the work $W = Q_1$ as shown in fig.

Thus if we consider the combined system of heat engine and heat pump, then it acts like a heat pump transferring the Q2 amount of heat from low temperature to high temperature reservoir without consuming any external work. Thus it violates the Clausius statement.

Violation on Clausius Statement:- Consider Heat pump, which violates the clausisus statement by transferrin Q_2 amount of heat from low temperature to high temperature body without consumption of work. Let assume the heat engine working between the same thermal reservoir which absorb Q_1 amount heat (which is greater than Q_2) and delivers work $W = Q_1-Q_2$ and reject the Q2 amount of heat to low temperature reservoir as shown in fig.

Thus if we consider the combined system of heat engine and heat pump, then it acts like heat engine which absorbs the Q1-Q2 amount of heat and develops the equivalent amount of work. Thus it acts

like heat engine exchanging heat single reservoir and producing an equal amount of work. This violates the Kelvin statement.

b) Classification of steam turbine **(02 marks each)**

i) According to Action of steam over moving blades

1) Impulse turbine

2) Reaction turbine

3) Impulse-Reaction turbine

ii) According to Expansion stages

1) Single stage turbine

2) Multistage turbine

iii) According to Pressure of steam entering

1) High pressure turbine

2) Low pressure turbine

iv) According to Exhaust steam pressure

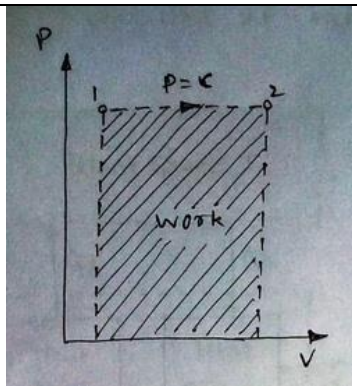
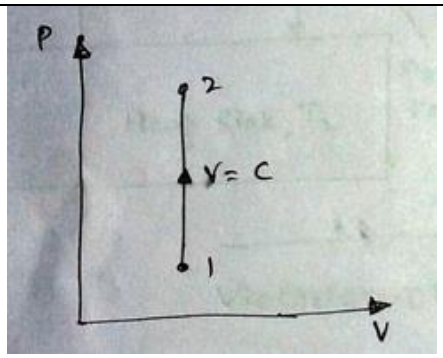
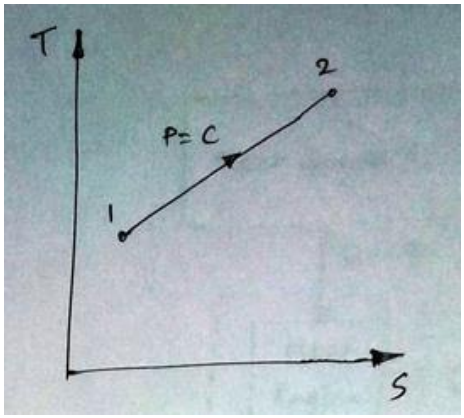
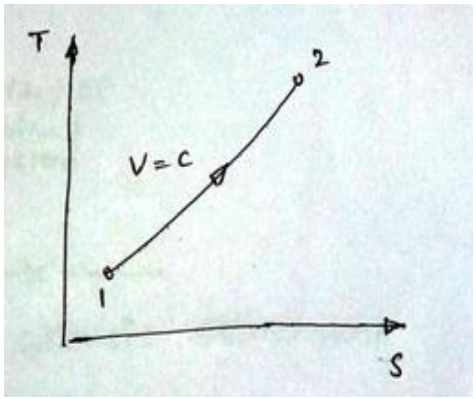
1) Condensing type steam turbine

2) Non condensing type steam turbine

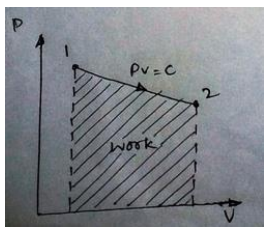
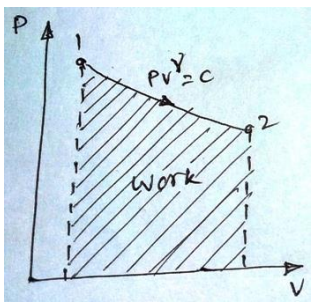
c) Difference between **Any 04, 01 mark each)**

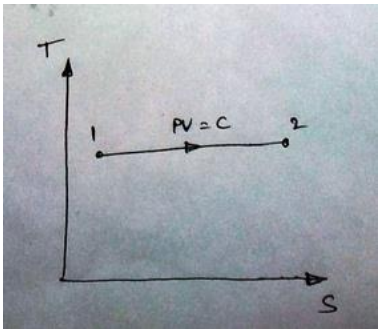
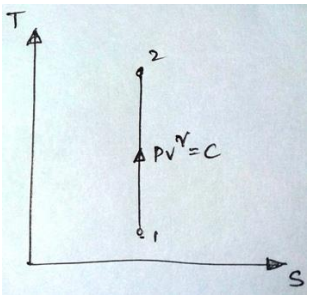
i) Isobaric and Isochoric process

Sr. No.	Isobaric Process	Isochoric Process
1	**Pressure** is constant during this process	**Volume** is constant during this process
2	**Volume is directly proportional to Temperature**	**Pressure is directly proportional to Temperature**
3	**Work done** during this process is calculated by **$P(V_2-V_1)$**	**Work done** during this process is **Zero**
4	P-V Diagram	P-V Diagram

		
5	T-s dia. 	T-s dia. 
6	Occurs in piston and cylinder arrangement	Occurs in closed vessel
7	Here specific heat at constant pressure (C_p) is assumed to be constant	Here specific heat at constant Volume (C_v) is assumed to be constant

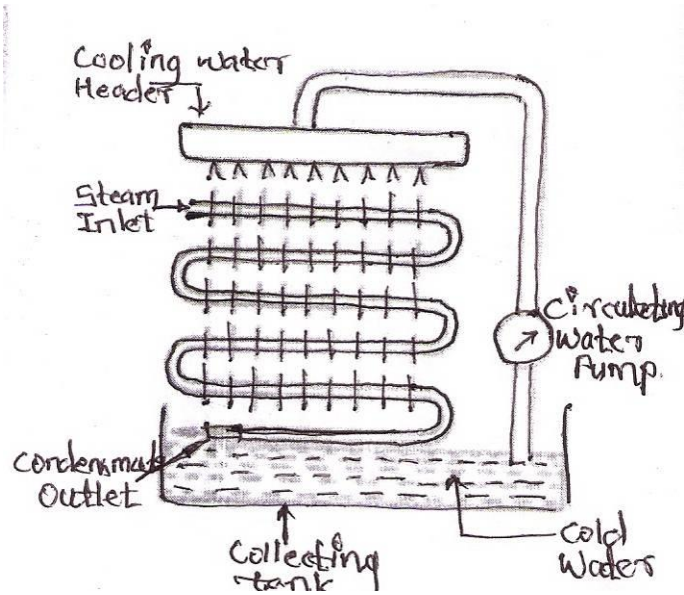
Isobaric and Isochoric process

Sr. No.	Isothermal Process	Adiabatic Process
1	**Temperature** is constant during this process	**Entropy** is constant during this process
2	**Change in internal energy is zero**	**Change in internal energy is calculated by formula as $mC_p (T_2-T_1)$**
3	P-V dig. 	P-V dig. 

4	T-s dia. 	T-s dia. 
5	Heat transfer is calculated by formula $P_1V_1\log e(V_2/V_1)$	Heat transfer is Zero
6	Work done dQ = dW	Work done dW = du = mC_vdT
7	Index n = 1	Index n = 1.4
8	Not achieved in practice due to friction i.e. ideal	Achieved inpractice

Q.6 a) Construction and working of evaporative condenser

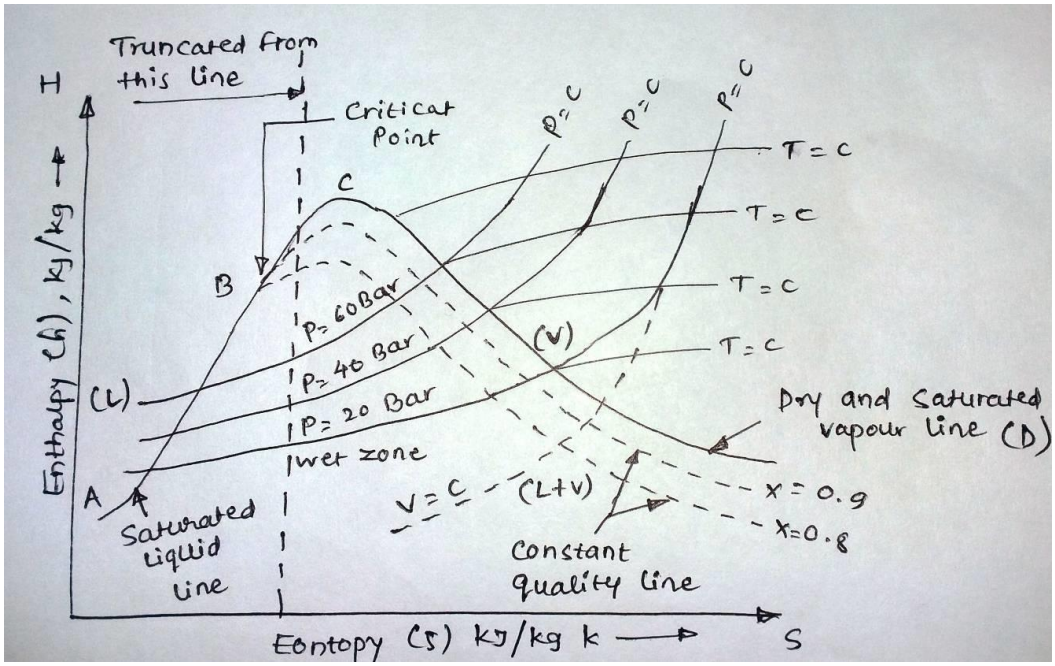
(sketch 04 , Explanation 03 , 01 marks application)



The steam to be condensed enters at the top of a series of pipes outside of which a film of cold water is falling. At the same time a current of air circulates over the water film, causing rapid evaporation of some of the cooling water. As a result of this, the steam circulating inside the pipe is condensed. The remaining cooling water is collected at an increased temperature and is reused. Its original temperature is restored by the addition of the requisite quantity of cold water. These condensers consist of sheets of grilled piping, which is bent backwards and forwards and placed in vertical planes as shown in figure.

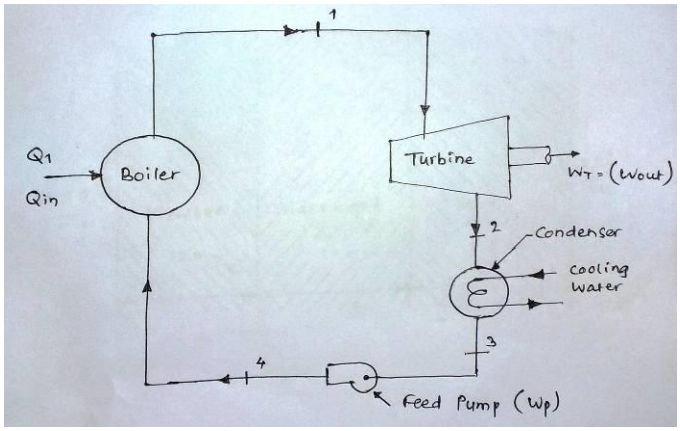
Application: - The evaporative condensers are provided when the circulating water is to be used again and again.

b) i) Mollier chart **(04 marks)**



ii) Ideal Rankine Cycle **(02 marks working , 02 marks P-V and T-S diagram**

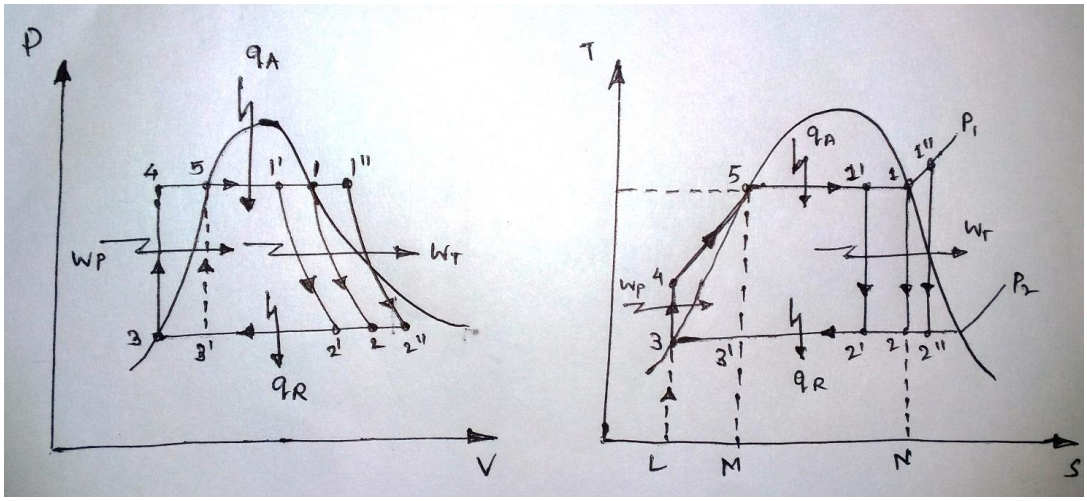
Rankine cycle is a theoretical cycle on which steam turbine (or engine) works



It consist of four elements

1) **Boiler :-** In boiler, the working fluid (water) receives heat by combustion of fuel and it is converted into steam.
2) **Steam turbine :-** In steam turbine, steam from the boiler pressure expands to delivery work of expansion.
3) **Condenser :-** In condenser, the exhaust steam from the turbine gives heat to cooling water and completely condenses to water.
4) **Feed Pump :-** Feed pump feeds the condensate from hot well to boiler at boiler pressure.

The Rankine Cycle is represented on P-V and T-S diagram as



c) i) Given Data :-

Thermal Conductivity for Steel (K_3)= 23.2 W/m^{0}K

Thermal Conductivity for Glass wool (K_2)= 0.14 W/m^{0}K

Thermal Conductivity for Plywood (K_1)= 0.052 W/m^{0}K

L_1 = 12 mm

L_2 = 20 mm

L_3 = 1.8 mm

T_1 = -10 ^{0} C = -10+273 = 263 ^{0}K

T_4 = 22 ^{0} C = 22+273 = 295 ^{0}K

Asked = $\frac{Q}{A}$

Solution :-

We know that

$$\frac{Q}{A} = \frac{T_1 - T_4}{\frac{L_1}{K_1} + \frac{L_2}{K_2} + \frac{L_3}{K_3}}$$

$$\frac{Q}{A} = \frac{263 - 295}{\frac{0.012}{0.052} + \frac{0.02}{0.14} + \frac{0.0018}{23.5}}$$

$$\frac{Q}{A} = \frac{-32}{0.231 + 0.143 + 0.0000766}$$

$$\frac{Q}{A} = \frac{-32}{0.3741}$$

$$\frac{Q}{A} = -85.544\, w/m^2$$

The negative Sign indicate that heat flow from outside to inside

C) ii) Heat exchanger use for

1) **Mills Chiller Plant :-** Plate type heat exchanger

Justification :-

a) Non-reactive material.

b) Leakproof joints

c) No mixing of two fluids

d) Non-toxic material

e) Non- corrosive material

2) **Radiator of an Automobile :-** Plate and tube type Heat Exchanger (Air Water Convective Radiator)

Justification:-

a) it is used to cool engine of automobile

b) Water flows though jacket along engine and carried away heat by convection

c) This water enter into radiator where it gives its heat to air of atmosphere which is pass over water tubes. Though plates.
