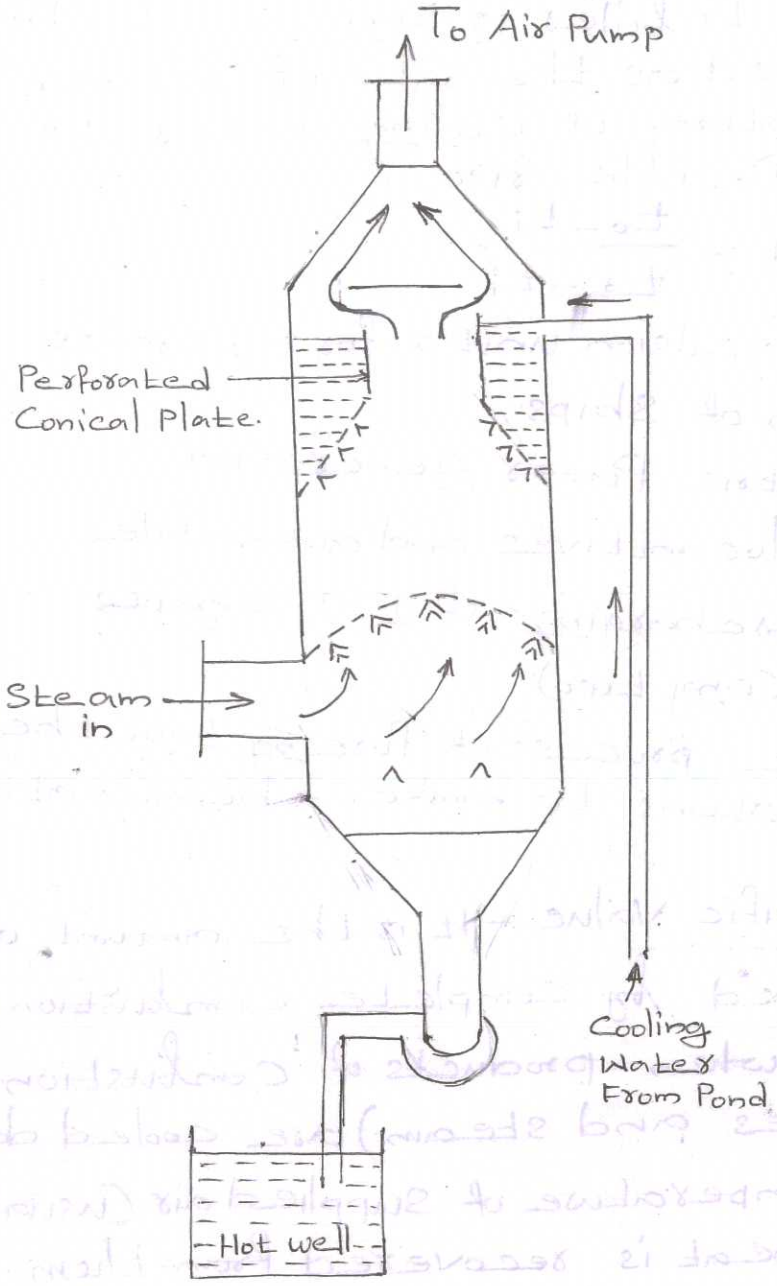
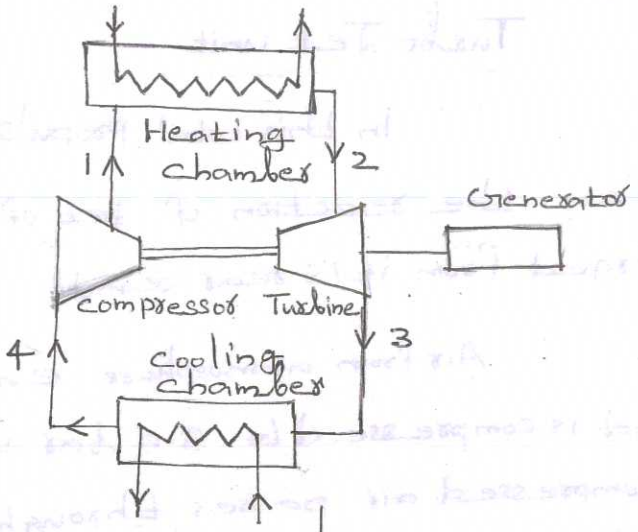
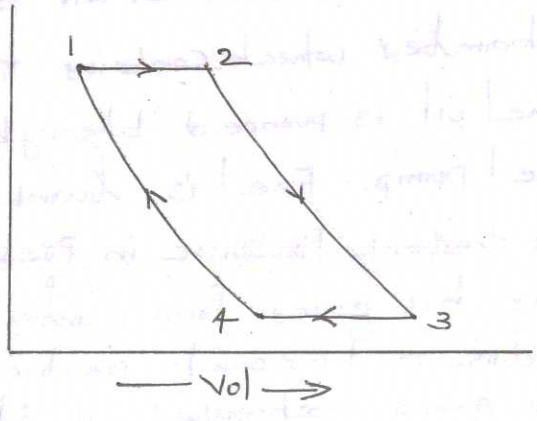
Power Plant Engineering

Code: (15) 5023

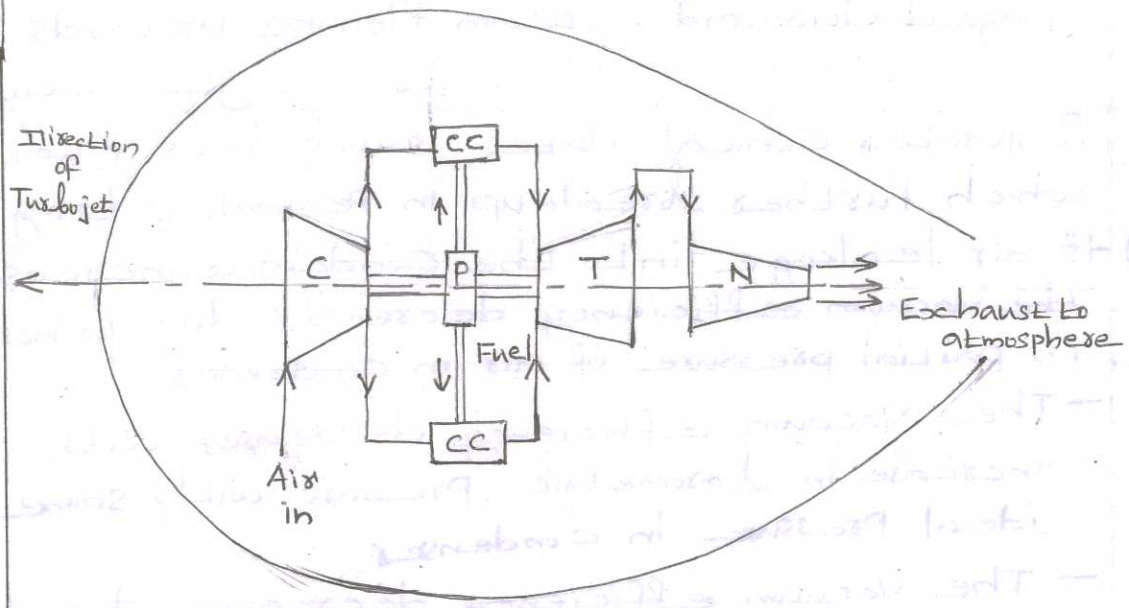
Qn No:	Scoring Indicators	Split Score	Total Score
I 1)	Time, Temperature, Turbulence	2	
2)	The process of draining steam from turbine at certain points during its expansion and using this steam for heating feed water to boiler is known as bleeding	2	
3)	It is defined as the ratio of actual rise in temperature of cooling water to maximum possible rise $\eta_{cond} = \frac{t_o - t_i}{t_s - t_i}$	2	10
4)	- In Jet Propulsion units for aircrafts - Propulsion of ships. - for electric Power generation - to run locomotives and automobiles - for supercharging of I.C engines (any two)	2	
5)	Fusion is the process of forcing together two light atoms to make a heavier atom	2	
II 1)	Higher Calorific Value - It is the amount of heat obtained by complete combustion of 1kg of fuel, when products of combustion (flue gases and steam) are cooled down to the temperature of supplied air (usually 15°C) and heat is recovered from them. Lower Calorific Value - It is the amount of heat obtained by complete combustion of	3	

Qn No:	Scoring Indicators	Split Score	Total Score
	1 kg of fuel when heat carried away by the products of combustion is not recovered and the steam formed during combustion is not condensed back to water (which is the actual practice)	3	6
2)		4	

In counter flow Jet Condenser steam enters at the bottom of the shell

Qn No:	Scoring Indicators	Split Score	Total Score
	while water is admitted at the top and Sprayed downwards. Steam flowing upwards Comes in contact with water and gets condensed. Perforated Conical Plate issues jets of water which further break up in Perforated trays.	2	6
3)	If air leakage into the Condenser increases, the vacuum efficiency decreases due to increase in partial pressure of air in condenser		
	– The vacuum efficiency decreases with increase in barometric pressure. with same ideal Pressure in condenser	1½×4	6
	– The vacuum efficiency decreases due to insufficient amount of cooling water circulated through condenser		
	– Vacuum efficiency depends on the rate at which air is removed by air pump		
4)		3	
	1-2 → Heating of air at Constant Pressure 2-3 → Isentropic expansion of air in Turbine 3-4 → Cooling of air at Constant Pressure 4-1 → Isentropic Compression of air in Compressor. 	3	6

Qn No:	Scoring Indicators	Split Score	Total Score



3

C - Compressor
CC - Combustion chamber
N - Nozzle
T - Turbine
P - Fuel Pump

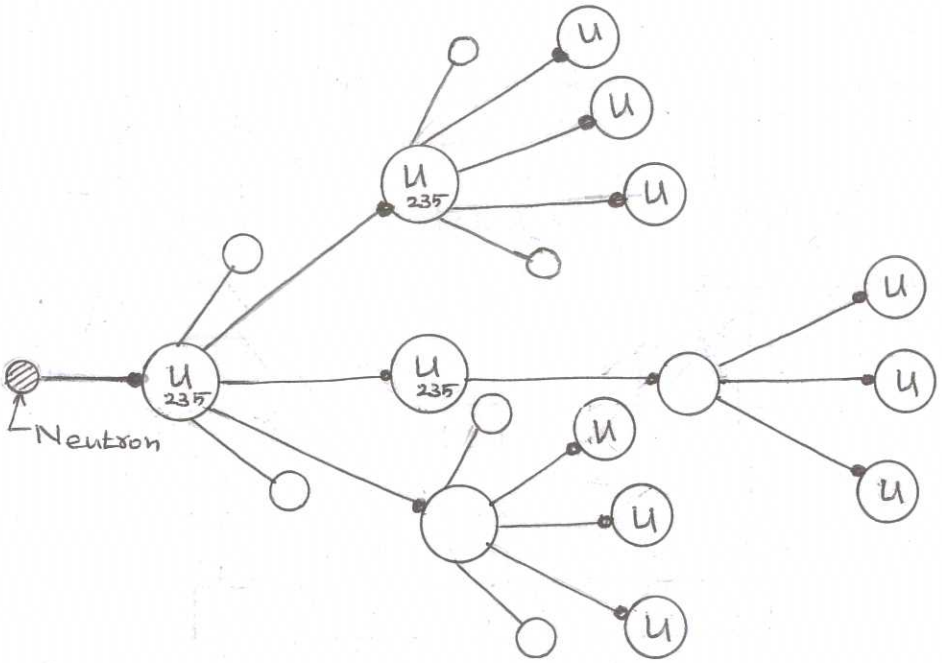
6

Turbo Jet unit

In this total propulsive force is obtained from the reaction of jet of exhaust gases discharged from it's rear end.

Air from atmosphere enters the Compressor and is compressed to 3.5 bar in rotary compressor. Compressed air passes through combustion chamber which contains ring of fuel nozzles. Fuel oil is pumped through these nozzles by fuel pump. Fuel is burnt in combustion chamber at constant Pressure in Presence of high pressure air. The hot gases from combustion chamber enters the turbine and expands producing Power. From turbine the gases exhausted out through Nozzle

3

Qn No:	Scoring Indicators	Split Score	Total Score
6)		3	6

When Uranium nucleus is bombarded with neutron, it split up into two fragments Barium and Krypton. In this process 3 additional neutrons are liberated with release of heat energy

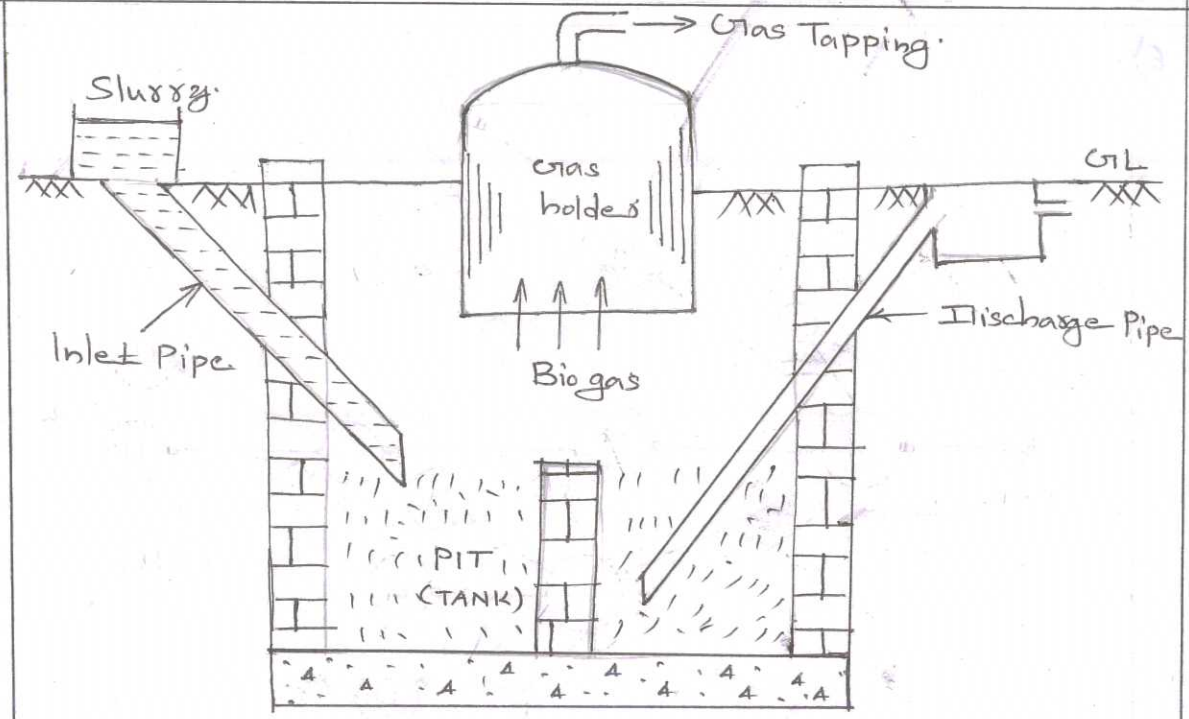
$$_{92}U^{235} + {}_{0}n^{1} \longrightarrow {}_{56}Ba^{144} + {}_{36}Kr^{89} + 3\,{}_{0}n^{1} + \text{energy}.$$

3

The 3 additional neutrons are called secondary neutrons. They in turn can causes ~~fo~~ fission in neighbouring nuclei producing more and more secondary neutrons. This is called chain reaction

Qn No:	Scoring Indicators	Split Score	Total Score

7)



3

Biogas is produced by bacterial decomposition of waste materials. The natural decay process "anaerobic decomposition" can be speeded up by using thermally insulated air tight tank with stirrer unit. called biogas digester.

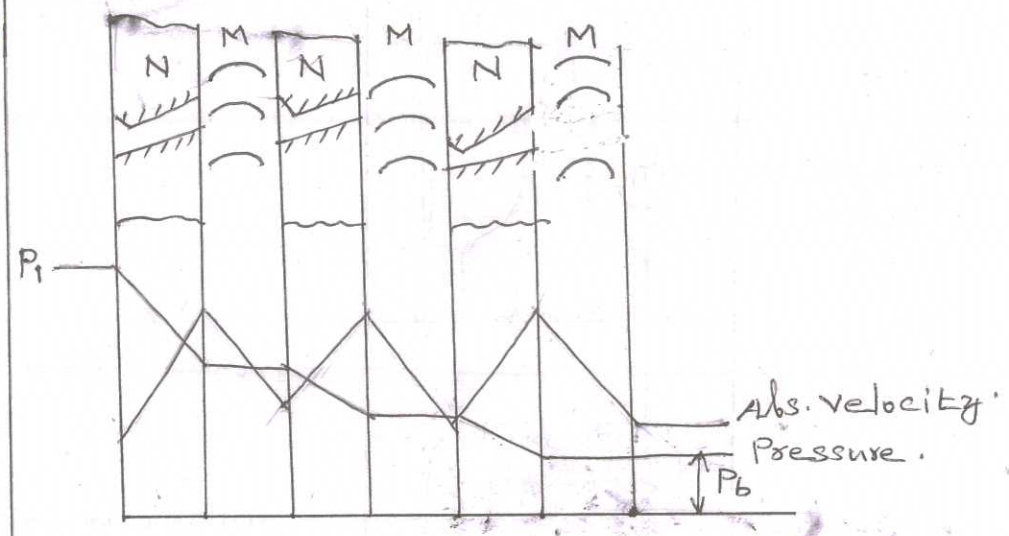
It contains a pit 1.5m dia and 4m deep excavated below the ground level. It is lined with bricks. The partition wall divides the space in pit into two compartments. The bottom of the pit is finished with cement concrete. Two slanting cement pipes reach the bottom of the pit on either side of the partition. One pipe conveys slurry from inlet into the pit and the other discharges the slurry (after digestion) to the sludge outlet. The outlet pipe dips lower into the pit than inlet pipe

6

3

Qn No:	Scoring Indicators	Split Score	Total Score

III a)



Pressure Compounding.

A number of simple impulse turbines arranged in series form a pressure compounded turbine. The entire pressure drop is distributed over number of stages; each stage consisting of nozzle ring followed by a ring of moving blades. The velocity is absorbed completely in moving blade ring and pressure is constant while flows through moving blade

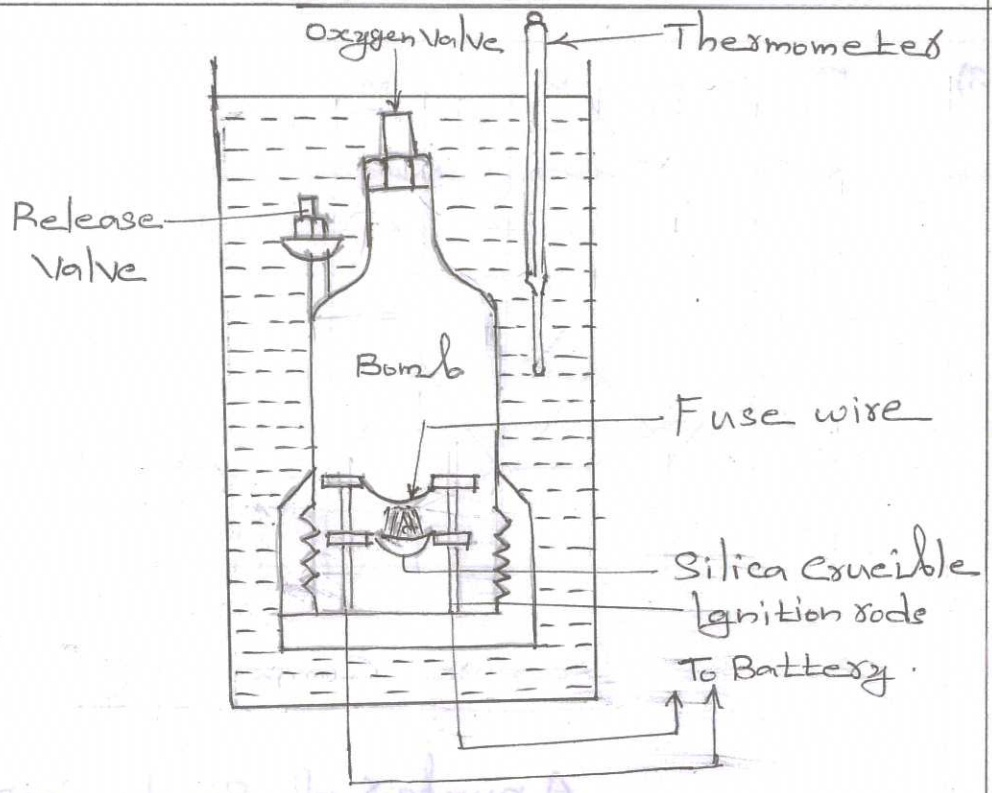
Split Score: 4 | Total Score: 8

b)
- Low Ignition Point
- High Calorific Value
- It should freely burn with high efficiency, once it is ignited
- It should not Produce any harmful gases.
- It should produce only least quantity of smoke and gases
- Economical
- Easy to store and convenient for transportation

Split Score: 1×7 | Total Score: 7

Qn No:	Scoring Indicators	Split Score	Total Score

IV a)



4

In this fuel is burnt at constant volume and at high pressure in a closed vessel called ~~Bomb~~ bomb.

8

A carrier ring supports Silica crucible, which in turn holds sample of fuel. By passing current through ignition wire, fuel is ignited. The bomb is completely immersed ~~in~~ in measured quantity of water. Heat liberated is absorbed by water and bomb. The rise in temp. of water is measured by a precision thermometer which reads up to 0.01°C

2

Heat liberated by fuel = Heat absorbed by water and apparatus

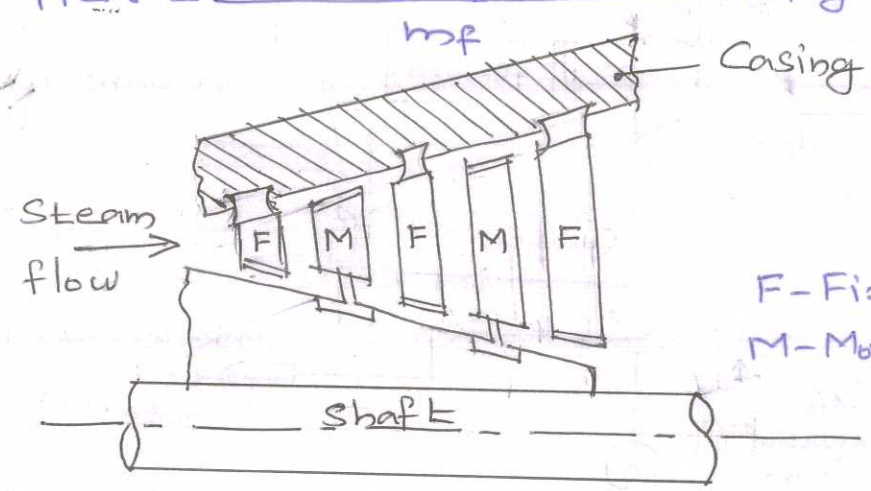
$$m_f \times HCV = (m_w + m_e) C_w \cdot \Delta t$$

2

m_f = mass of fuel, m_w = mass of water, m_e = water equivalent of Apparatus and Δt = temperature rise of water
C_w = Sp. heat of water

Qn No:	Scoring Indicators	Split score	Total score

b) $HCV = \frac{(m_w + m_e)\, C_w \cdot \Delta t}{m_f}$ kJ/kg.



F - Fixed Blade
M - Moving Blade

4

It consists of a rotor to which rings of moving blades are mounted. Fixed or guide blades are fixed inside the casing. Steam flows alternately through fixed and moving blades. There is continuous fall of pressure as steam expands through blades. Fixed blades serves as guide blades as well as nozzles. Volume of steam gradually increases and hence size of low pressure side should be bigger.

3

7

V a) The water is heated and steam is generated in a steam boiler and high pressure Superheated steam is fed to the steam turbine. The superheated steam expands in steam turbine and heat energy is converted to mechanical energy. Since generator is coupled with steam turbine,

Qn No:	Scoring Indicators	Split Score

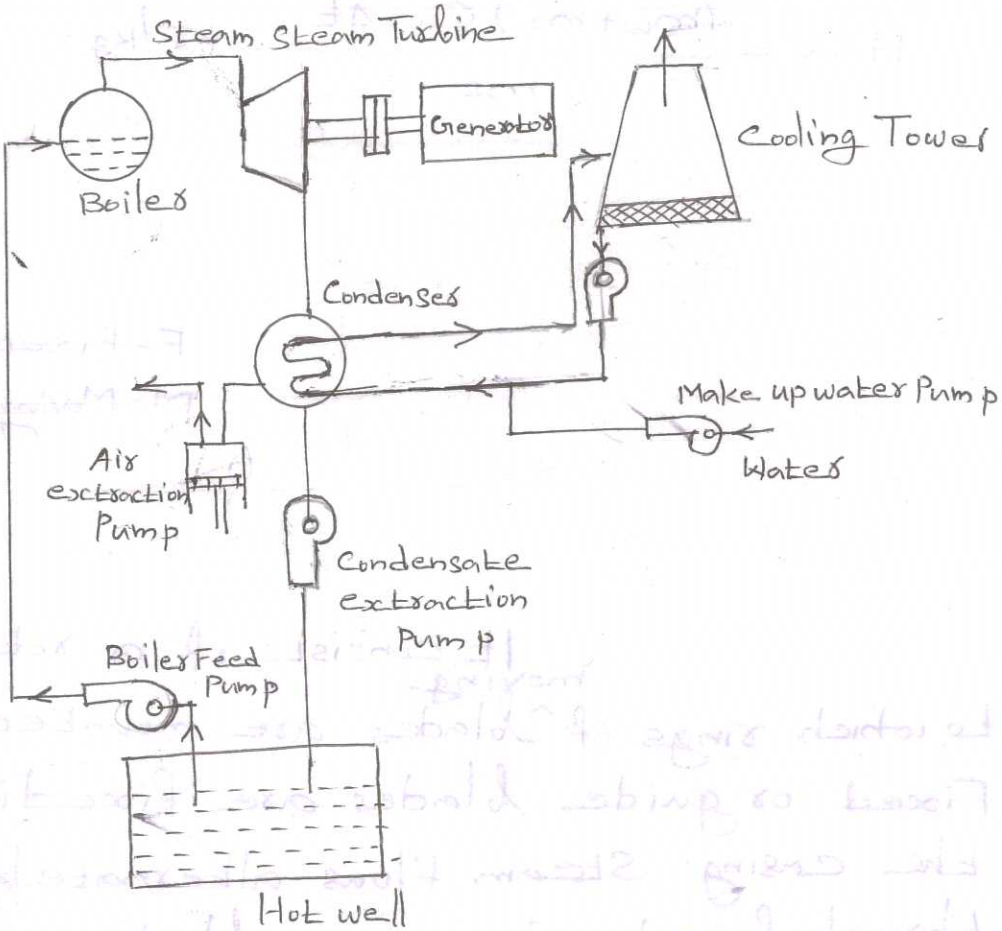


Fig - 4 marks

generator rotates and electrical energy is generated

After expansion in turbine, the LP steam enters into the condenser, where it transfers its latent heat of condensation to the circulating cooling water in condenser with the help of cooling tower and gets condensed. The condensate is extracted by condensate extraction pump and pumps into a hot well from where it is pumped back to boiler along with feed water. Thus the cycle goes on and repeats. (4 marks)

b) Condensate temperature = 31°c

From steam Tables, ideal Pressure = 0.04491 bar

= 0.04491 × 750.06 (3 marks)

= 33.68 mm of Hg.

Qn No:	Scoring Indicators	Split Score	Total Score

Ideal Vacuum = Barometric Pressure − Ideal Pr.

= 760 − 33.68

= 726.32 mm of Hg.

2

$$\eta_{Vacuum} = \frac{\text{Actual Vacuum}}{\text{Ideal Vacuum}}$$

7

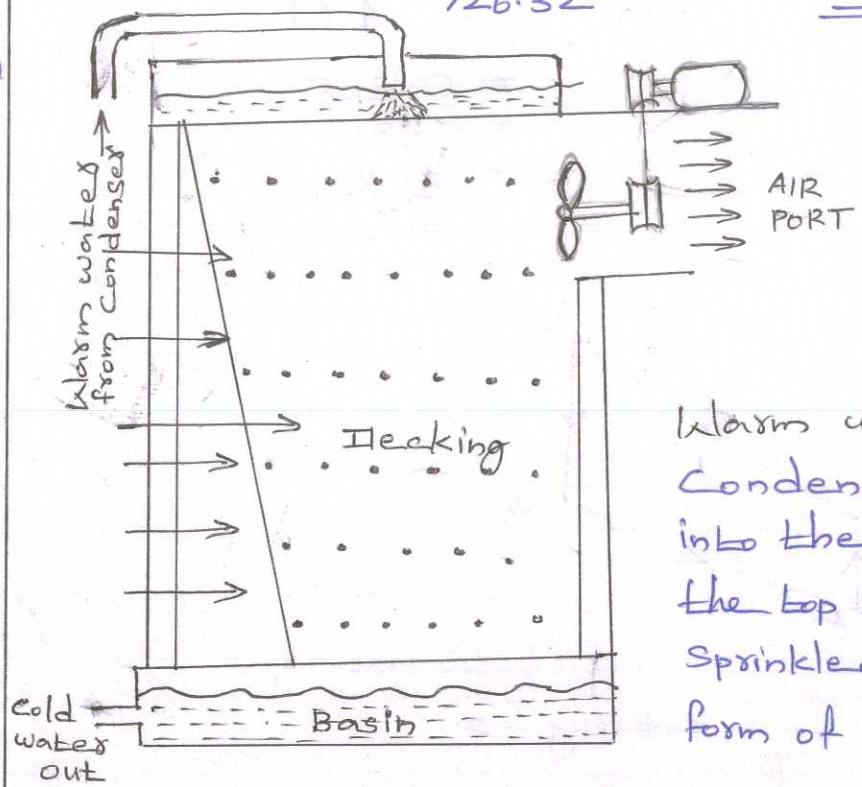
Vacuum gauge reading = Actual Vacuum

Actual Vacuum = 705 mm of Hg.

2

$$\therefore \eta_{Vacuum} = \frac{705}{726.32} = 0.97 = 97\%$$

VI a)



4

Induced draught Cooling Tower

Warm water from condenser is admitted into the tower at the top section. It is sprinkled down in the form of broken spray

Atmospheric air is sucked from the top at velocity from 70 to 100 m/min. Fine particles of water comes in contact with unsaturated air drawn from atmosphere into the tower. Air being at low DBT than that of water, it absorbs

sensible heat. It also absorbs some amount of water particles from falling water and in this process some water particles evaporate. ~~Evapor~~ Evaporation causes cooling of non-evaporated bulk of water which drops to the bottom of the tower. warm humid atmospheric air leaves the tower from top — 4 8

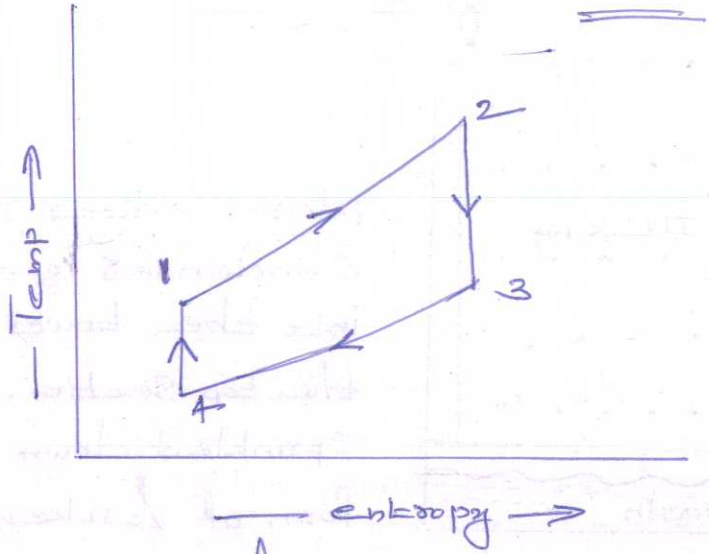
b) From Steam Tables, corr. to Pr. of 12 bar (T_1) = 188°C = 461K — 1½

Corr. to Pr. of 0.1 bar (T_2) = 45.83°C = 318.83K — 1½

$$\eta_{Carnot} = \frac{T_1 - T_2}{T_1} = \frac{461 - 318.83}{461} \quad 7$$

$$= 0.308$$
$$= 0.31$$
$$= 31\% \quad 4$$

VII a)



2

$P_3 = P_4 = 1$ bar

$T_4 = 15°C = 288K$

$P_1 = P_2 = 5$ bar

$T_2 = 800°C = 1073K$

$C_p = 1 kJ/kgK$

Qn No:	Scoring Indicators	Split Score	Total Score

For Isen. Compn process 4-1

$$\frac{T_4}{T_1} = \left[\frac{P_4}{P_1}\right]^{\frac{\gamma-1}{\gamma}} = \left[\frac{1}{5}\right]^{\frac{0.4}{1.4}} = 0.631$$

$$\therefore T_1 = \frac{T_4}{0.631} = \frac{288}{0.631} = 456\,K$$

Temp. of air at the end of Compn = 456 K

For Isen expn. process 2-3

$$\frac{T_3}{T_2} = \left[\frac{P_3}{P_2}\right]^{\frac{\gamma-1}{\gamma}} = \left[\frac{1}{5}\right]^{\frac{0.4}{1.4}} = (0.2)^{0.286} = 0.631$$

$$\therefore T_3 = T_2 \times 0.631 = 1073 \times 0.631 = 677\,K$$

Temp. of air at the end of expn = 677 K

Work done by the turbine / kg of air (W_T)

$$= C_p (T_2 - T_3)$$
$$= 1(1073 - 677)$$
$$= 396\ kJ/kg$$

8

b) In hydro electric Power Plant, the potential energy of water stored in a dam is utilised to run the turbine which in turn run the electric generator to produce electric Power. The important elements are

1. Reservoir 2. Dam 3. Penstock 4. Surge tank 5. Valve house 6. Power House.

When high pressure water from Penstock enters the nozzle, the Potential

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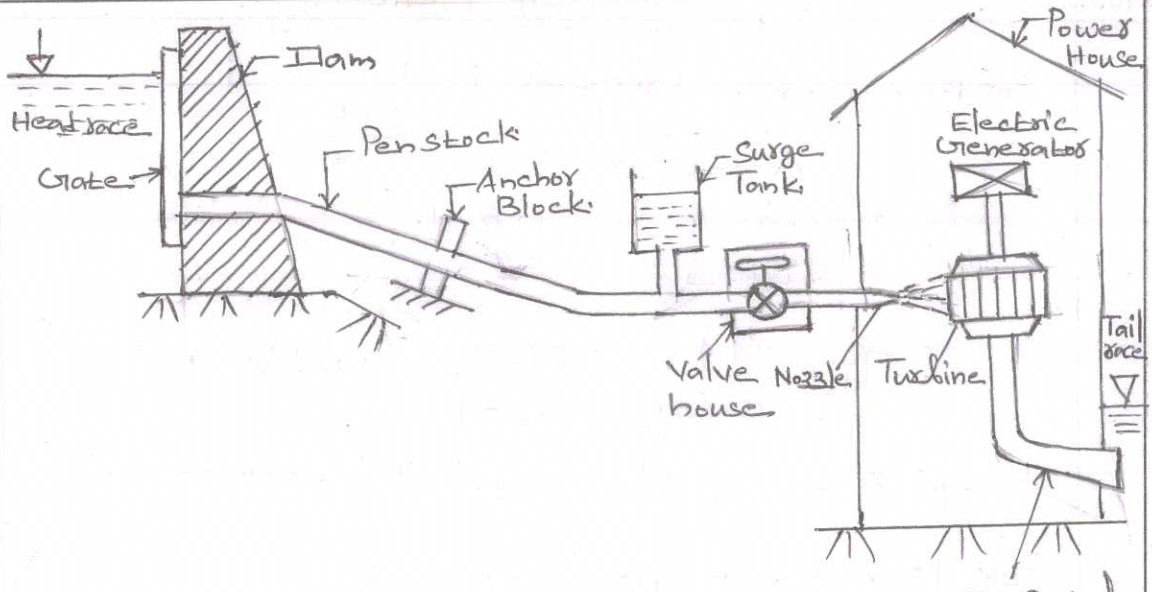


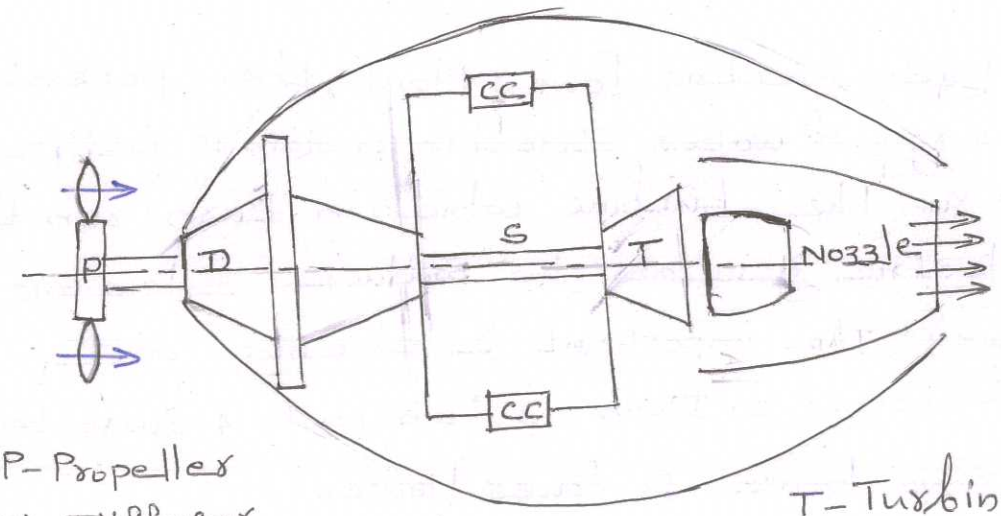
4

energy of water is converted to kinetic energy and it comes out from the nozzle in the form of jet with high velocity. This high velocity jet strikes on the runner of the turbine and the runner rotates at high speed. Thus kinetic energy of water is converted to rotary motion of runner. As the turbine is coupled with generator, it also rotates and electrical power is generated. The water after striking the turbine blades, leaves to tail race.

7

3

VIII a)



4

P - Propeller
D - Diffuser
CC - Combustion chamber
S - Coupling shaft
T - Turbine

Qn No:	Scoring Indicators	Split Score	Total Score

It obtains it's driving force from the action of propeller as well as from the reaction of jet of burnt gases ejecting from it's rear. The expansion of jet takes Place partly (80%) in turbine and Partly (20%) in nozzle.

Air enters the compressor, where it is compressed to high pressure. The compressed air is then passed into the combustion chamber where combustion of fuel takes place. The products of combustion expands inside the turbine and Power is developed which drives Propeller and compressor. The exhaust gases form into jet and leave unit from it's rear end. A propulsive force is obtained due to reaction of this jet. The overall efficiency is improved by providing diffuser before compressor

4 | 8

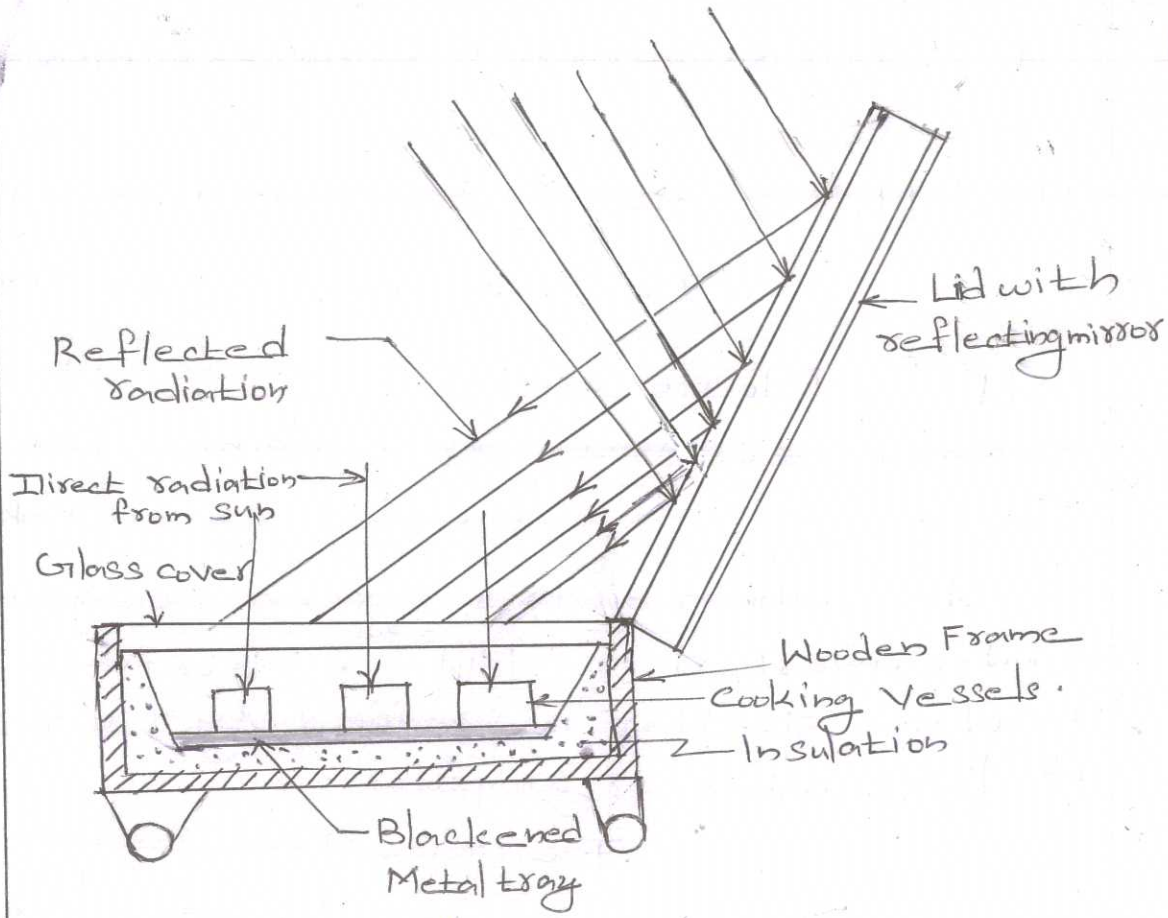
b) - Gas turbine has no reciprocating Parts and is free from vibrations.
- Installation and running cost is less.
- Lubrication is simpler.
- No flywheel is required, since torque Produced is uniform.
- It has simplified cooling system
- It has higher mechanical efficiency
- It's exhaust is free from smoke
- It can be driven at high speed and is suitable for aircrafts.
- Since combustion is continuous, there is no Problem of ignition timings.

1x7 | 7

(Carry seven)

Qn No:	Scoring Indicators	Split Score	Total Score
IX a)	i) Active Core – It contains mainly fissionable material (nuclear fuel). The fuel may be in solid form such as rods, plates or spheres. The common fuels are U^{235}, U^{233}, Pu^{239} etc.	2	8
	ii) Moderator – The function of moderator is to slow down the fast neutrons travelling at 4200 km/s to about 1.5 km/s before subsequent fission occurs. Eg – Graphite, Heavy water, Light water etc.	1½×4	
	iii) Control rods – These are used to absorb neutrons to control reaction. Eg – Cadmium, Boron		
	iv) Thermal shielding – It surrounds entire reactor core and is made of iron. Coolant flows over this to take away heat.		
	v) Biological shield – The entire reactor is kept inside ~~it~~ it to prevent leakage of neutrons, X-rays & β Particles		
b)	It consists of a rectangular enclosure insulated on bottom and sides having one or two glass covers on the top. Food to be cooked is placed in shallow vessels. Solar radiations enters through the top and heats up the vessels. Temperature around 100°c can be obtained in such		

Qn No:	Scoring Indicators	Split Score	Total Score



4

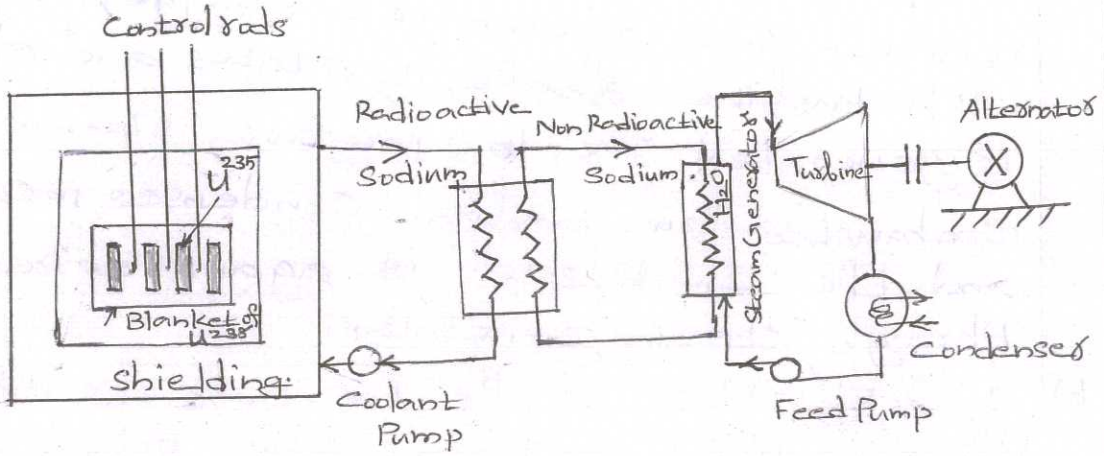
7

solar cooker

~~It consists of are cookers~~ ~~on~~ Sun cookers on sunny days. The cooking time is ~~inverse~~ proportional to collector Panel area.

3

X a)



4

Fast Breeder Reactor Plant

Additional neutrons produced when U^{235} is fissioned, coverts U^{238} into fissible

Qn No:	Scoring Indicators	Split Score	Total Score

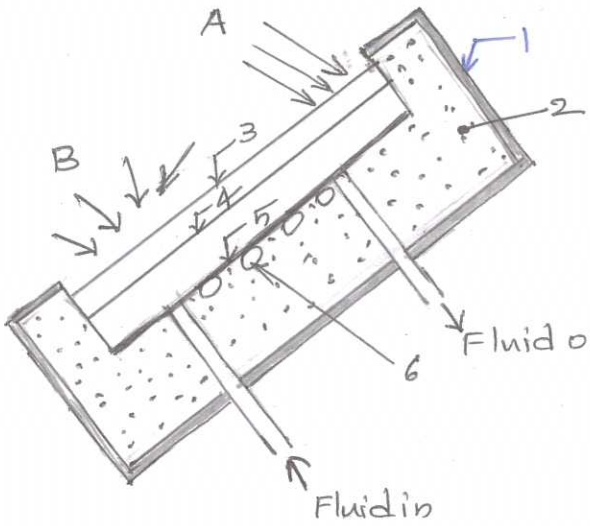
Pu^{239}. This substance is capable of maintaining chain reaction. Producing fissible material than that is consumed is called breeding.

The fuel used in FBR core is U^{235}. No moderator is used. Liquid sodium is used as coolant. The central U^{235} is surrounded by a blanket of U^{238}, which absorbs excess neutrons and converted to Pu^{239}. Necessary neutron shielding is provided by the use of light water or graphite.

The radioactive sodium circulated through reactor transfers heat to non radioactive sodium circulated through secondary loop. The non radioactive sodium transfers heat to water in steam generator and steam is generated. The steam expands in turbine, and mechanical work is done. Since alternator is coupled directly with turbine shaft, it rotates and electricity is generated. The low pressure steam exhausted from turbine condenses in condenser and the condensate is again recirculated through steam generator. 4 8

b) Solar Flat Plate collector consists of an absorber plate on which the solar radiation falls. The absorber plate is coated with black coke powder and it acts as a black body absorber. The absorber plate is

Qn No:	Scoring Indicators	split Score	Total Score



1. Casing
2. Thermal Insulation
3,4 Glass covers
5. Absorber Plate
6. Fluid Passage
A. Direct Beam
B. Diffuse radiation

4

Flat Plate Collector

covered by one or two glass plate, which acts as a heat trap. The sides and bottom of the box are insulated. It absorbs both direct and diffuse radiation. The sunlight passes through the glass plates and is absorbed by absorber plate.

The absorbed radiation is Partly transfered to liquid flowing through tubes which are fixed on the bottom of absorber Plate. The glass cover helps in ~~reding~~ reducing ~~tosess~~ losses by convection and re-radiation, while thermal insulation reduces losses by conduction.

7

The liquid commonly used is water and temperature involved is below 100°c. The collector is usually held tilted in a fixed Position on a supporting structure.

3