SUMMER-19 EXAMINATION

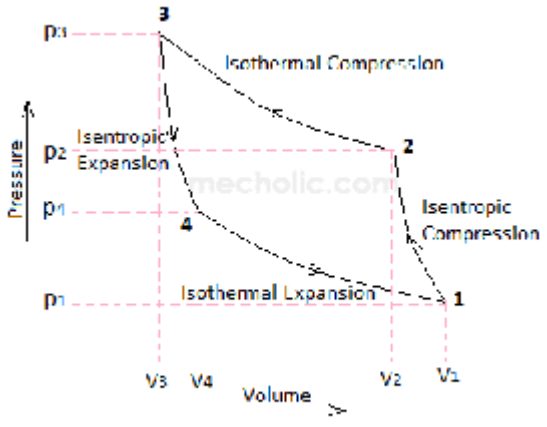
Model Answer

Subject title: Plant Utilities Subject code 22311

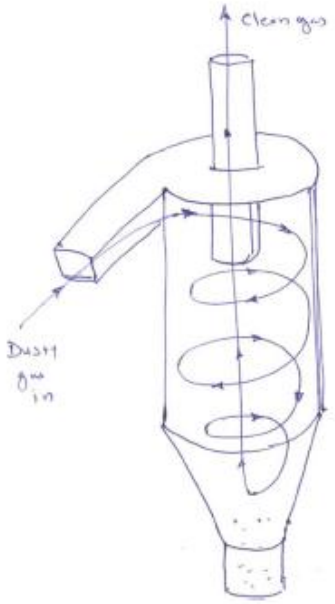
Important Instructions to examiners:

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.		Answer	Marking scheme
1		**Attempt any five**	**10**
1	a	**Temporary hardness**: It is the hardness developed in water due to presence of dissolved bicarbonates of calcium and magnesium. It is destroyed by boiling of water. **Permanent hardness**: It is the hardness developed in water due to presence of chlorides and sulphates of calcium, magnesium or other heavy metals. It is destroyed by chemical process.	1 1
1	b	**Enthalpy of dry saturated steam.** It is the quantity of heat required to raise the temperature of 1 kg of water from the freezing point to the boiling point and then convert it into dry saturated steam at that temperature and pressure.	2
1	c	**Types of steam:** 1. Dry saturated steam 2. Wet steam 3. Superheated steam	2
1	d	**Define refrigeration:** Refrigeration is defined as the science of providing and maintaining temperatures below that of surrounding atmosphere. **Unit of refrigeration** is **Ton of refrigeration**	1 1
1	e	**Diagram of reversed Carnot Cycle:**	2

		 **Fig(1) p-v diagram**	
1	f	**Principle of cooling tower:** A cooling tower is a heat rejection device which rejects waste heat to the atmosphere through the cooling of water stream to a lower temperature. Cooling towers may either use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature or, in the case of closed circuit dry cooling towers, rely solely on air to cool the working fluid to near the dry-bulb air temperature	2
1	g	**Working principle of humidifier**: If unsaturated air is passed through a spray of continuously recirculated water the specific humidity will increase while the dry bulb temperature decrease. This is the process of adiabatic saturation or evaporative cooling **OR** A humidifier pushes moisture into the air, increasing the levels of humidity in the air and improving the conditions in rooms and buildings for those people in them.	2

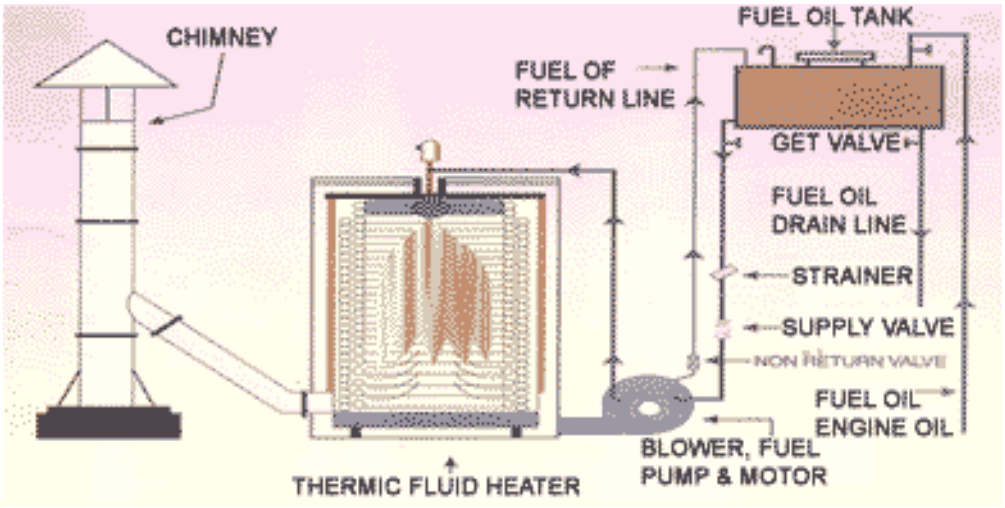
2		**Attempt any three**	**12**
2	a	**Differentiate between hard water and soft water: (any 4)** **Hard water** | **Soft water** 1.Contains dissolved salts of calcium and magnesium | Does not contain dissolved salts of calcium and magnesium 2.Does not produce lather or foam with soap | produce lather or foam with soap 3.Treatment is required before using | No treatment required 4.Can't be directly used in boiler | Can be used directly in boiler	I mark each
2	b	Mass of dry steam = 49kg Mass of water in suspended form = 1 kg Condition of steam : Wet steam Dryness fraction = 49/50 = **0.98** Enthalpy of water at 5 bar (from steam table) = **640.1kJ/kg**	1 1 1 1
2	c	**Cyclone separator** **Working** A dust laden gas enters in a cyclone separator takes spiral motion. It utilizes a centrifugal force generated by spinning gas stream to separate particle matter from the gas. The centrifugal force on a particles in spinning gas stream is much greater than gravity, there for it is effective in removing small particles. The gas spirals downwards to the bottom of the cone and at, and at the bottom the gas flow reverses to form an inner vortex which leaves through the outlet pipe. Cyclone separator is used to separate gas-solid, gas-liquid in Cement industry, Oil refinery, Petrochemical Plant, Power plants, and Metallurgical Industry etc.	2

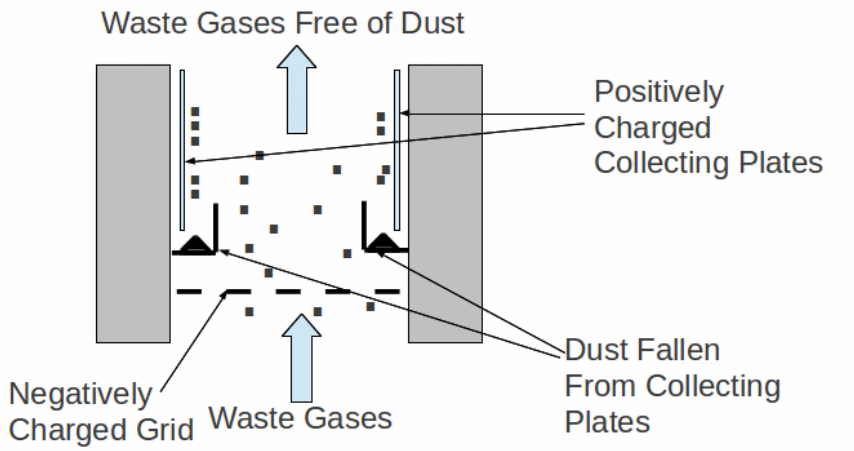
			2
2	d	**Comparison of fire tube and water tube boiler: (any 4)**	1 mark each

	Fire tube boiler	**Water tube boiler**
1) Furnace position	Inside boiler shell	Outside shell
2)Drum size	Large	Small
3)Heating area utilization	Not effective	effective
4)Use of fuel	Not used very efficiently	Effectively utilized by multipass flow
5) Overheating or tube failure	Furnace surrounded by water, so danger of overheating is less as long as water level is maintained.	Furnace not surrounded by water, so if circulation of water inside tube is not proper, tube failure can occur.

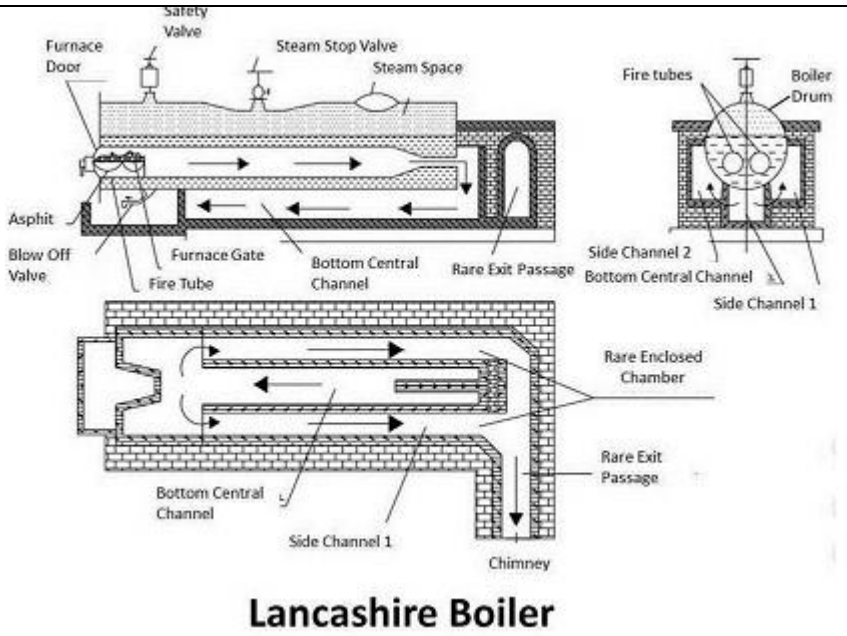
		6)High pressure	Making large drum for high capacity and high pressure is very difficult	Drum size small, so drum can be made very strong for very high pressure.		
		7) Production of steam	Generates low pressure steam	Generates high pressure steam		
		8) Space	More space	Less space		
		9) Operating cost	Low	High		
		10) Scale formation	Low	Chances are high		
3		**Attempt any three**				**12**
3	a	Given: Hard water contain 1 mg $CaCl_2$ and 1 gm of $MgCl_2$ Solution: Step1 : conversion of the quantities of all the chemicals in terms of $CaCO_3$ equivalent in ppm:				1
		Sr.no.	chemicals	Quantity in mg/lit	Molecular weight	Types of hardness	$CaCO_3$ equivalent in ppm	1
		1	$CaCl_2$	1	111	Non-carbonate	1 x (100/111) = 0.900 ppm	1
		2	$MgCl_2$	1	95	Non-carbonate	1 x (100/95) = 1.0526 ppm	1
		Total hardness = 0.900 + 1.0526 = 1.9526 ppm						1
3	b	**Ion exchange bed remedial action to avoid bed exhaust**:						

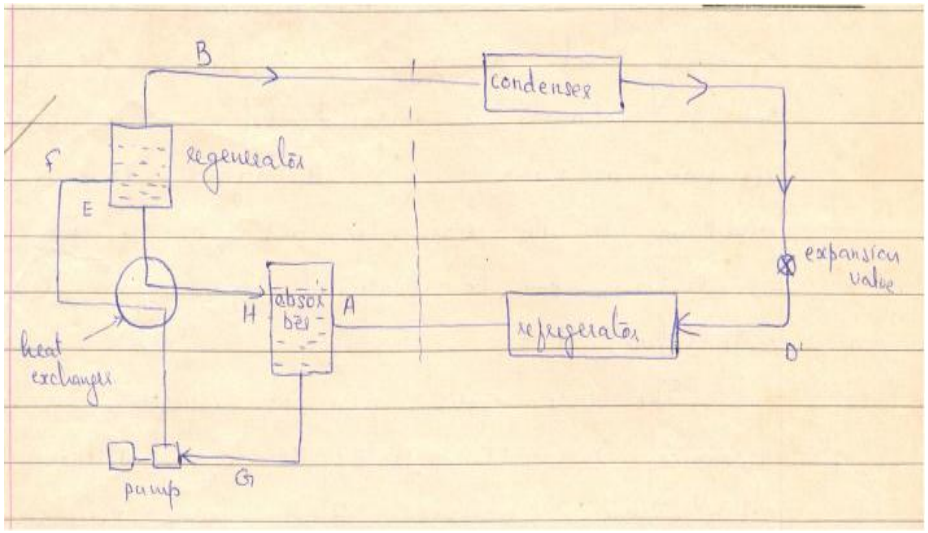
		1. Avoid presence of suspended solids 2. Water containing oils and greases are not used. 3. Water containing bacteria and algae not used 4. Water containing organic substance are not used After exhausting bed regenerate bed by using: The exhausted cation exchanger is then regenerated by passing dilute solution of acid (i.e. dilute HCl or dilute H_2SO_4) $RCa + 2\,HCl \rightarrow RH_2 + CaCl_2$ The washing containing $CaCl_2$ is passed to drain. The exhausted anion exchanger is then regenerated by passing dilute solution of alkali (i.e. dilute NaOH) $R`Cl_2 + 2\,NaOH \rightarrow R`(OH)_2 + 2\,NaCl$	2 2
3	c	**Construction and working of thermic fluid heater**: **Construction:** Thermic fluid heater consist of two concentration coils in which inner coil act as a radiation zone and our coil act as conversion zone. Flue gas velocity is generally higher the 2 coils and between the coil and outer shell, so higher the velocity higher will be the convective heat transfer between the flue gas and fluid. Thermic fluid heater can be made either 3 pass or 4 pass depending on the design of thermic fluid heater and types of fluid to be burnt.	1

		Working: The maximum temp. of 350 deg. C of thermic fluid can be achieved . Thermic fluid heater also consist of deaerator and expansion tank . the density of fluid decreases with increase in temperature , so tank is help to accommodate the extra volume of the fluid which is increase due to increase in temperature . Deaerator tank is combined with expansion tank and used to vent air from the fluid which act as a resistance in transferring of heat to the fluid.  	1 2
3	d	**Electrostatic precipitator**: Diagram:	4

			
4		**Attempt any three**	**12**
4	a	**Caustic embrittlement**: **Causes:** Use of highly alkaline water Boiler which operate under high pressure Presence of sodium bicarbonate during softening process **Preventive measures**: By using sodium phosphate for softening of water By adding tannin and lignin as a additives By adjusting the alkalinity of water	2 2
4	b	**Duties of boiler inspector:** Confirm all boilers are registered. Make sure that all boilers are working according to act. Check and examine boilers ,their parts and mountings etc. Advice the employer of boilers regarding the matters of boiler maintenance, cleaning etc.	4

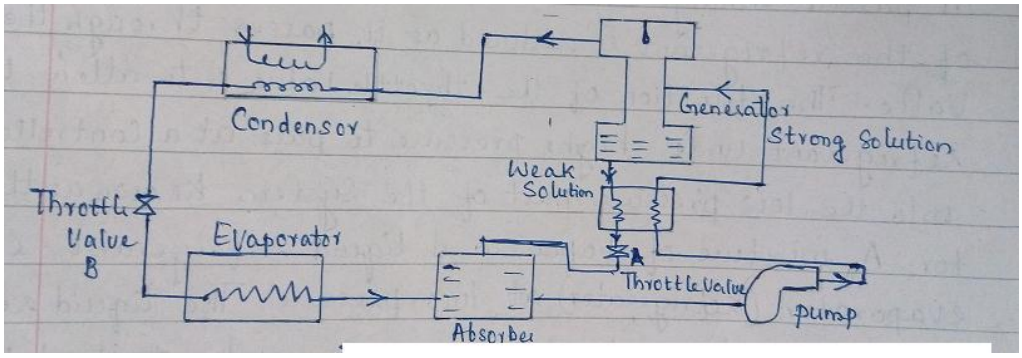
		Maintain the record of registered boilers. Examine boilers inspection reports produced by inspector. Decide whether to issue the certificate for the operation of boiler or not. Supervise and control the work of inspector.	
4	c	**Type of Lancashire Boiler:** **It** is a horizontal type and stationary fire tube boiler. Flue gases pass through the fire tube. It is present inside the boiler shell or body and for this reason, it is a fire tube boiler. Lancashire Boiler is an internally fired boiler. It is a natural circulation boiler. The flue gases pass through the fire tubes and water flows through the shell. Flue gas can pass from one side to another side, inside the boiler fire tube. Then the backward flue gases pass from the bottom passage of this boiler. After this process remaining flue gases pass from the side passage of the boiler. **Diagram:**	2

		 **Lancashire Boiler**	2
4	d	**Application of process air:** i) To clean work shop ,generators and machine. ii) For cooling of furnace. iii) Compressed air used in oxidation of acetaldehyde to acetic acid in liquid phase reactor. iv) Oxidation of nitrogen oxide to nitrogen dioxide in nitric acid plant. iv) To exhaust the fumes of HCl gas, by exhaust blower. v) fan air used in solid fuel boiler.	1 mark each for any 4
4	e	**Uses of**: (i) **Scrubber(any 2)** -Used in filtration devices that removes fine particles like dust and smoke. - Wet scrubber apply energy directly to the flowing fluid medium. -Used in pharmaceuticals industry	1 mark each

		(ii) Air dust collector(any 2): 1. Used to recover valuable granular solid or powder from process. 2. To remove granular solid pollutant from exhausted gases.	1 mark each
5		**Attempt any two**	**12**
5	a	**Vapour Absorption Refrigeration system**  In absorption system the compressor in the vapor compression cycle is replaced by an absorber- generator assembly involving less mechanical work. Ammonia is the refrigerant and water is the absorbent. Ammonia vapor is vigorously absorbed in water. So low pressure ammonia vapor from the evaporator comes in contact in the absorber with a weak solution coming from the generator, it is readily absorbed releasing the latent heat of condensation. The temperature of the solution tends to rise, while the absorber is cooled by the circulating water , absorbing the heat of solution, Q_A and maintaining a constant temperature. Strong solution, rich in ammonia, is pumped to the generator where Q_G is supplied from an external source like steam, electricity etc. Since the boiling point of ammonia is less than that of water, the ammonia	3 marks for diagram and 3 marks for description

vapor is given off from the aqua- ammonia solution at high pressure and the weak solution returns to the absorber through a pressure reducing valve. The heat exchanger preheats the strong solution and cools the weak solution, reducing both Q_A& Q_G. The ammonia vapor then condenses in the condenser, is throttled by the expansion valve, and then evaporates absorbing the heat of evaporation from the surroundings

OR



Lithium Bromide absorption system uses LiBr salt as absorbent and water as refrigerant. Pure LiBr is solid, but when mixed with sufficient water, homogeneous liquids are formed. There are four major components of the system –absorber, generator, condenser and evaporator. The heat is added to the generator from an external source. Throttle valve A reduces the temperature and pressure of the weak solution thus enhancing absorption. Throttle valve B reduces pressure thereby producing cooling. LiBr has the property to absorb water due to its chemical affinity. As the concentration of LiBr increases, its affinity towards water increases. As temperature increases, its affinity decreases. Since LiBr is nonvolatile, in the generator, only water is

<table>
<tr><td></td><td></td><td>driven off.</td><td></td></tr>
<tr><td>5</td><td>b</td><td>Different thermic fluids are:
1. Dowtherm A
2. Dowtherm E
3. Therminol FR
4. Oil mobiltherm 600
5. Oil Mobiltherm light
6. Hydrotherm 750-200
Thermic fluid with temperature range:
<table>
<tr><td></td><td>Thermic fluid</td><td>Temp. Ranges (deg. F)</td></tr>
<tr><td>1</td><td>Dowtherm A</td><td>53.6 – 495.8</td></tr>
<tr><td>2</td><td>Dowtherm E</td><td>-6.7 to 352</td></tr>
<tr><td>3</td><td>Therminol FR</td><td>50-600</td></tr>
<tr><td>4</td><td>Oil mobiltherm 600</td><td>20(pour pt.) to >600</td></tr>
<tr><td>5</td><td>Oil Mobiltherm light</td><td>-20(pour pt.) to >400</td></tr>
<tr><td>6</td><td>Hydrotherm 750-200</td><td>5 (pour pt.) to ---</td></tr>
</table></td><td>3
3</td></tr>
<tr><td>5</td><td>c</td><td>Outside air temperature (DBT)= 32^0C
Relative humidity(ψ) = 60%
(i) Specific humidity (ω) = 0.01kg/kg dry air.
(ii) Enthalpy (h) =77kJ/kg dry air (They are inclined straight lines and uniformly spaced.
(iii) Wet bulb temperature (Twb) = 25^0C
(iv) Dew point temperature (Tdp) = 62^0C (They are horizontal ie parallel to the abscissa and non-uniformly spaced)
(v) Specific volume of dry air (v) = 0.887m^3/dry air</td><td>1
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1
1
1
1</td></tr>
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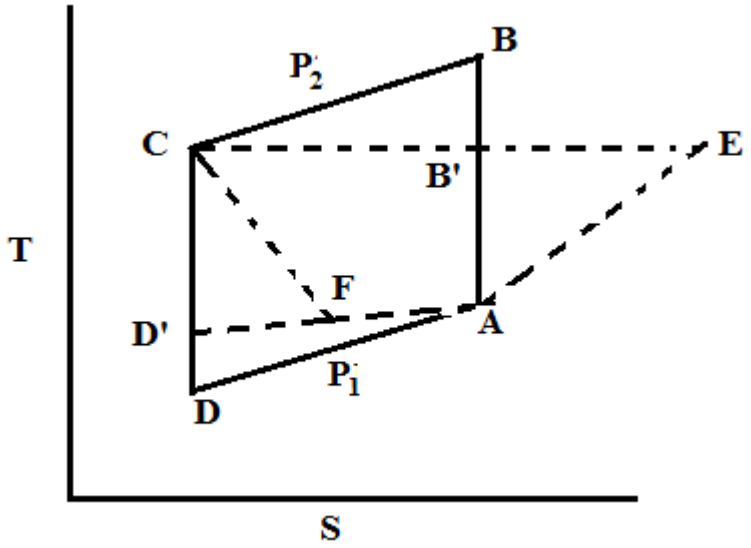
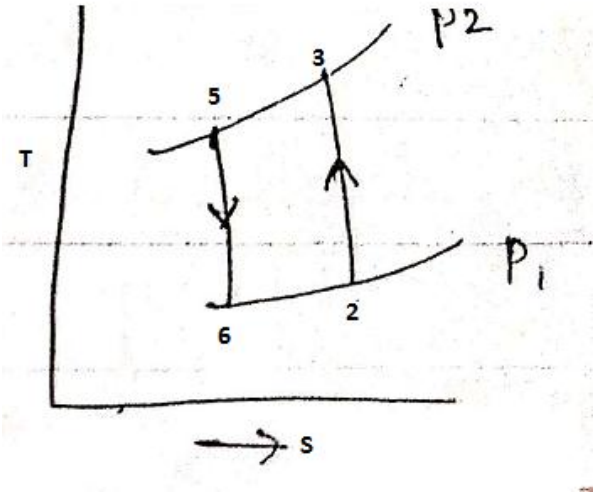
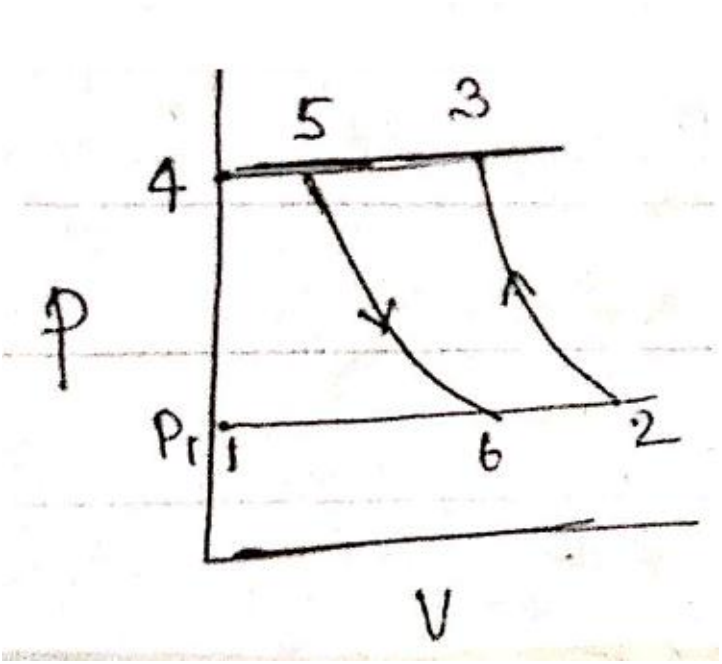
6		**Attempt any TWO of the following**	**12**
6	a	**PV and TS diagram for air refrigeration cycle:**  Or  	3

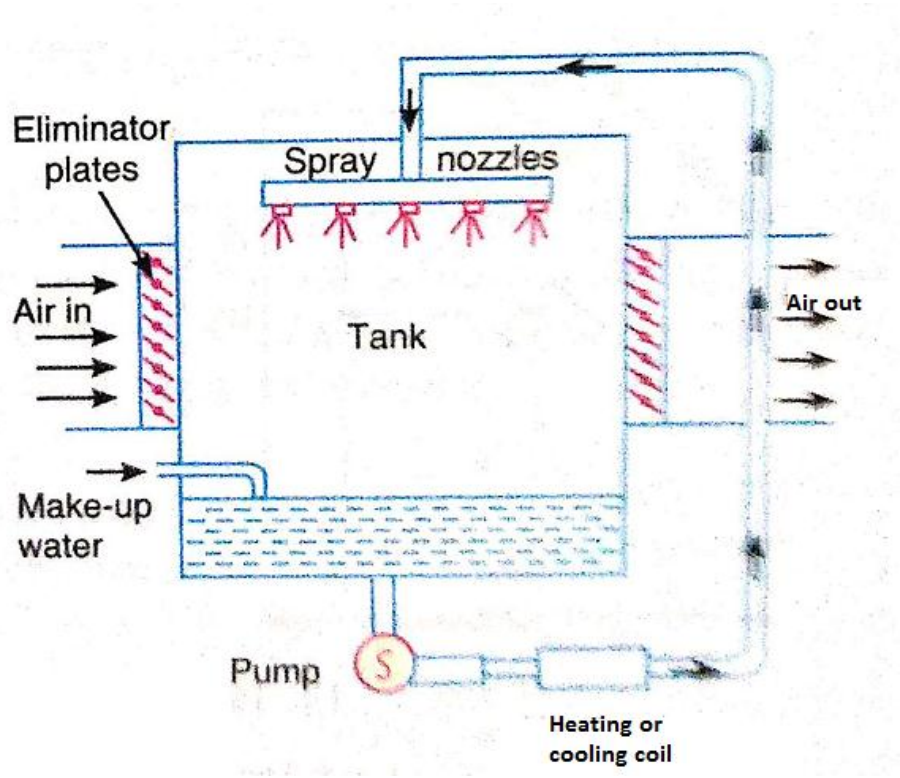
		PV Diagram  1-2 Suction of air into compressor 2-3 Isentropic compression 3-4 Discharge of high pressure air from compressor into heat exchanger. 5-6 Isentropic expansion of air in the expander. 6-2 Absorption of heat at constant pressure.	3
6	b	**Dehumidifier:** **Principle:** When humidity ratio of air decreases, air is said to be dehumidified. Air may be dehumidified by (i) Placing the evaporator coil across the air flow (ii) Circulating chilled water or brine in a tube placed across the air flow (iii) Spraying chilled water to air in the form of mist to expose a large	2 mark for any one point

surface area.

Construction and working

The dehumidification is accomplished with the help of an air washer or by using chemicals. In the air-washer system, the outside or entering air is cooled below its dew point temperature so that it loses its moisture by condensation. The moisture removal is also accomplished when the spray water is chilled water and its temperature is lower than the dew point temperature of the entering air. Since air leaving the air washer has its dry bulb temperature much below the desired temperature in the room, a heating coil is placed after the air washer. 2

Diagram



2

6	c	**Various boiler problems due to boiler feed water are:** **1.Scale and sludge formation:** When hard water is evaporated in boiler, the concentration of soluble salts of calcium and magnesium reaches saturation point and they are thrown out along with other soluble impurities in the form of precipitate. If the precipitate forms a hard adhering coating on the inner walls of the boiler, it is called scale. If the precipitation takes place in the form of loose and slimy precipitate, it is called sludge. They are formed at comparatively colder portions of the boiler where the flow rate is low. **2.Caustic embrittlement:** It is a type of boiler corrosion caused by using highly alkaline water in high pressure boilers. In high pressure boilers Na_2CO_3 decomposes to give NaOH and CO_2 and NaOH flows into the minute hair cracks . In the cracks water evaporates and the caustic soda dissolves iron of the boiler. This causes embrittlement of the boiler parts. **3. Boiler corrosion**: It is the decay of boiler material by chemical or electrochemical attack by its environment created by using unsuitable water. It is caused due to dissolved oxygen, dissolved $CO_2$and dissolved salts present in water.Dissolved oxygen can destroy the protective hydrogen film that can form of many metals and oxidize dissolved ions into insoluble forms. Deposits of rust in a plumbing system is such an example of differential aeration cells and accelerate corrosion **4. Priming and foaming:** **Priming**: It is the phenomenon of very rapid boiling of water inside the boiler with the result that the water particles mixed up with steam. It is due to the presence of	1 1 1 1

		large quantities of dissolved organic oily matter, suspended material etc. **Foaming** : It is the phenomenon of formation of foam or bubbles on surface of water which do not break easily. **Priming and foaming can be prevented by** i)controlling the concentration of impurities inside the boiler ii) By keeping the level of water as low as possible. iii) By addition of anti foam agents like gallic acid, cotton oil etc iv) By use of blow down of boiler sludge.	1 1