SUMMER-16 EXAMINATION

Model Answer

Subject code :(17425)

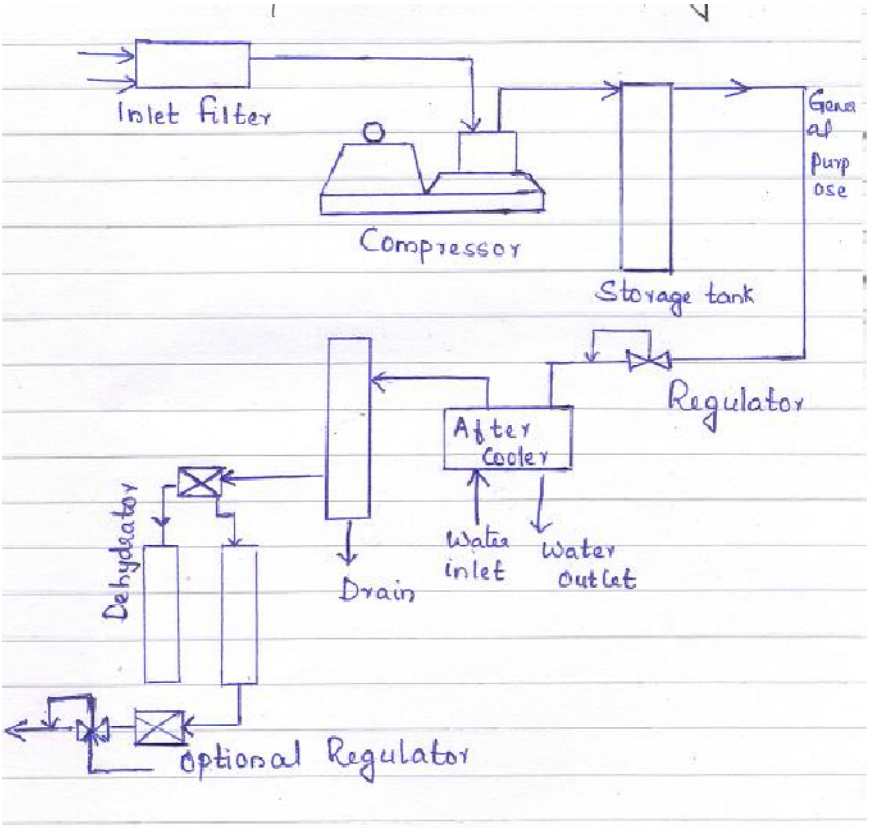
Important Instructions to examiners:

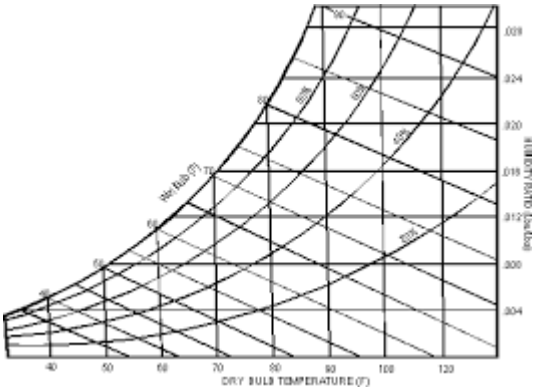
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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.

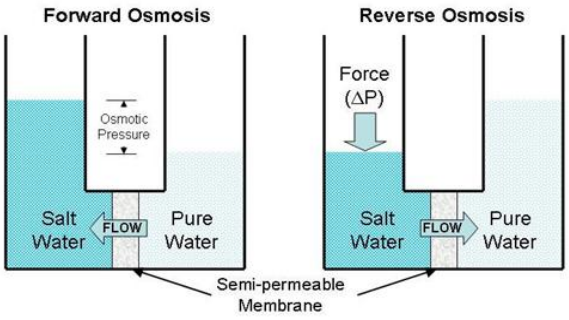
Q No.	Answer	Marks	Total marks
1 a	Attempt any six		12
1a-i	**Unit of refrigeration** is **Ton of refrigeration**: It is defined as the quantity of heat required to be removed from 1Ton water at 0^oC to get ice at 0^oC in one day **Coefficient of Performance**.: working performance of any machine is usually expressed by output/input ratio known as efficiency. In refrigeration it is denoted by C.O.P. (β). COP= refrigeration effect/ work input to produced R.E. β =RE/W	1 1	2
1a-ii	**Important refrigerants used for refrigeration:** 1. Ammonia 2. carbon dioxide 3.sulphur dioxide 4. isobutene 4. Methyl chloride 5. methylene chloride 6. Freon-22 7. Freon-11 8. Freon 12	½ mark each for any four	2
1a-iii	**Hard water:** Contains dissolved salts of calcium and magnesium. It Does not produce lather or foam with soap**.** **Soft water:** Does not contain dissolved salts of calcium and magnesium. It produces lather	1 1	2

<table>
<tr><td></td><td>with soap</td><td></td><td></td></tr>
<tr><td>1a-iv</td><td>Use of steam trap:
They are used to collect and automatically discharge the water resulting from partial condensation of steam without allowing any steam to escape.</td><td>2</td><td>2</td></tr>
<tr><td>1a-v</td><td>Importance of insulation in refrigeration:
Insulators are substances with low thermal conductivity. Since low temperature is maintained in refrigeration than outside temperature heat flow should be prevented from outside to inside to maintain the cooling effect. Therefore it is to be insulated.</td><td>2</td><td>2</td></tr>
<tr><td>1a-vi</td><td>Water tube and fire tube boiler (any 2)
<table><tr><th>Water tube boiler</th><th>Fire tube boiler</th></tr><tr><td>Content of tube is water</td><td>Content of tube is hot gas</td></tr><tr><td>Hot gas surrounds the tube</td><td>Water surrounds the tube</td></tr><tr><td>Eg babcock and Wilcox boiler</td><td>Eg. Cochran boiler, locomotive boiler</td></tr></table></td><td>1 mark each</td><td>2</td></tr>
<tr><td>1a-vii</td><td>Temporary hardness:
It is the hardness developed in water due to the presence of dissolved bicarbonates of of calcium and magnesium. It is destroyed by boiling of water.
Heat
$Ca(HCO_3)_2$ -----.$CaCO_3$ +H_2O + CO_2
heat
$Mg(HCO_3)_2$ -----. $Mg(OH)_2$ + 2 CO_2</td><td>1

1</td><td>2</td></tr>
</table>

1 b	**Attempt ant two**		8
1b-i	**Instrument air:**  Air is passed through a filter to remove suspended impurities. The filtered air is supplied to the compressor. Discharge from the compressor will be at a pressure of 100 to 150 psi, which is stored in a storage tank. When required it is passed through a regulator and then through an after cooler to remove the heat. It is then passed through a stone filter to remove traces of oil if present. Filtered air is passed through dehydrator to remove the moisture. Silica gel, activated alumina, calcium chloride, glycol etc are used for removing the moisture. A second pressure regulator is sometimes added to provide a	2 2	4

	constant reduced pressure in the supply line		
1b-ii	**Psychrometric chart**  The dry bulb temp. is indicated by vertical lines drawn parallel to the ordinate. The mass of water vapour in kg per kg of dry air is drawn parallel to the abscissa for different valued of dry bulb temp. Pressure of water vapour in mm of Hg is shown in the scale at left and is the absolute pressure of steam. Dew point temp. Re shown in the scale on the upper curved line. Constant RH Lines in per cent are indicated by marking off vertical distances between the saturation line or the upper curved lines and the base of the chart **Uses:** The psychrometric chart are prepared to represent graphically all the necessary moist air properties, used for air conditioning calculations. The values are based on actual measurements verified for thermodynamic consistency	2 2	4
1b-iii	**Inspection of boiler:** Boiler is inspected before the certificate for its operation is given to its employer. Before inspecting the boiler, It is clean	4	4

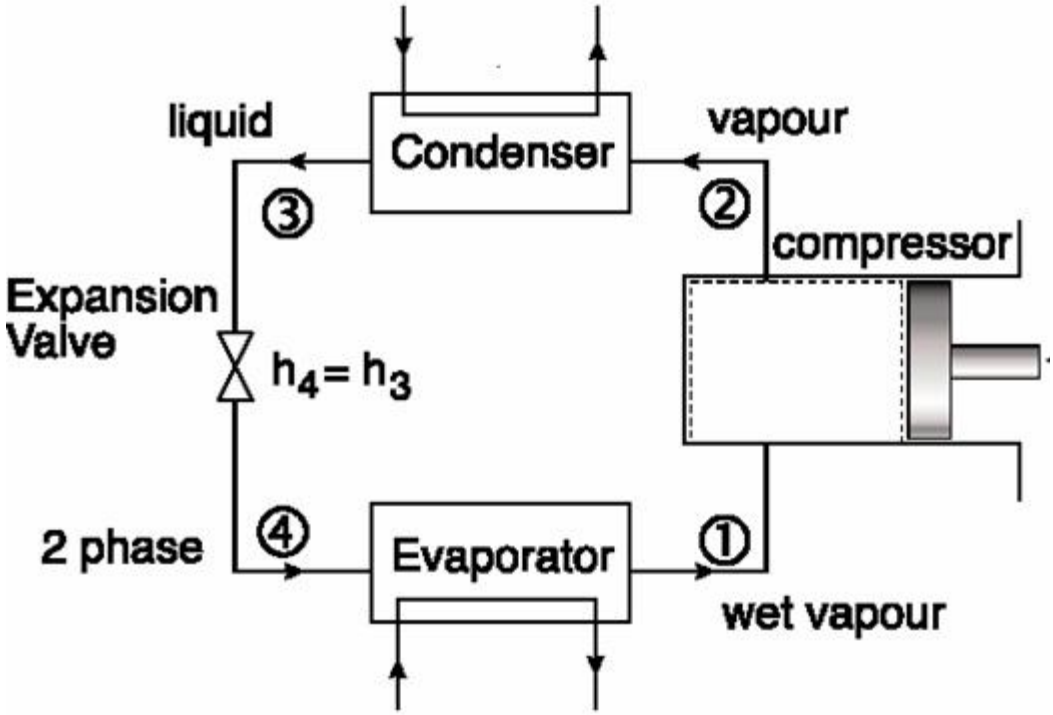
	All fittings , such as burners , stokers, etc are removes Valves, cocks etc are open & inspector examine all the parts of boiler, carries the hydraulic test , where the water pressure is raised to hydraulic test pressure of 1.5 psi When the hydraulic test pressure is reached, the boiler is inspected for water leakage if any.		
2	**Attempt ant four**		16
2-a	**Reverse osmosis:**  **Description:** It is the process of filtration. In this , we take water with salt in it , an apply pressure to it against a certain type of membrane and presto out comes clean water. Two chamber are separated by an osmotic membrane. Right hand compartment has pure water in it. Left hand compartment has salt solution. If left alone , pure water floe in the direction of the arrows from the pure water compartment into salt solution compartment. Pressure heas in the salt solution compartment continue to rise until it reaches a value represented by the osmotic pressure of the solution. Then flow of water stops. In the same chamber divided by the osmotic membrane , if increasing pressure is applied on the salt solution compartment in the direction of the arrow , then	2 2	4

	the first drop of pure water flows in the direction of the arrow from the solution compartment to the pure water compartment when the applied pressure equal the osmotic pressure value of the solution. The applied p must be much greater than the osmotic pressure. Description: It is the process of filtration. In this , we take water with salt in it , an apply pressure to it against a certain type of membrane and presto out comes clean water. Two chamber are separated by an osmotic membrane. Right hand compartment has pure water in it. Left hand compartment has salt solution. If left alone , pure water floe in the direction of the arrows from the pure water compartment into salt solution compartment. Pressure heas in the salt solution compartment continue to rise until it reaches a value represented by the osmotic pressure of the solution. Then flow of water stops. In the same chamber divided by the osmotic membrane , if increasing pressure is applied on the salt solution compartment in the direction of the arrow , then the first drop of pure water flows in the direction of the arrow from the solution compartment to the pure water compartment when the applied pressure equal the osmotic pressure value of the solution. The applied p must be much greater than the osmotic pressure.		
2-b	**Methods for removal of scales:** Scales can be removed 1. With the help of scraper or piece of wood or wire brush, if they are loosely adhering. 2. By giving thermal shocks ,if they are brittle. 3. By dissolving them by adding some chemicals, if they are adherent and hard.	1/2 mark each for any four	4

	4. By frequent blow down operation, if they are loosely adhering. I f the scale is hard, it can be removed by using some chemical reagent depending upon the composition of scale. Calcium carbonate, sulphate scales can be removed by use of 5-15% HCl as it is readily soluble in it or sulphate scale can be removed by using EDTA solution.	2	
2-c	**Dry bulb temperature:** Temperature recorded by ordinary thermometer is called dry bulb temperature. **Wet bulb temperature:** It is the temperature indicated by a thermometer whose bulb is covered with a wetted cotton At dew point temperature, both temperatures are equal	1.5 1.5 1	4
2-d	**Effect of hard water used for domestic purpose:** 1. Cooking: The presence of calcium and magnesium salts in water increases the boiling point of water. Hence more fuel and time are required for cooking certain food material. 2. Drinking: hard water is not suitable for drinking because presence of salty impurities have bad effect on digestion process. Continuous use of hard water may cause calcium oxalate crystals formation. 3. Washing: Hard water if used for washing purpose does not produce lather freely with soap. It produces white precipitates and this continues till all salts are precipitated.. Then soap starts formation of lather with soap. This results in wastage of soap. 4. Bathing: The precipitate formed deposits on skin and hairs. Cleaning quality of soap is decreased and it is wasted.	 1 1 1 1	4
2-e	**Industrial application of refrigeration:** 1. Comfort air conditioning of auditorium, hospital, offices, residences etc.	1 mark each for any 4	4

	2. Manufacture and preservation of medicine 3. Preservation of blood and human tissues 4. Storage and transportation of food stuff such as meat, fruit, fruit juice, vegetables etc. 5. Ice cooling of concrete for dam.		
2-f	**Process air, instrument air and compressed air:** **Process air:** The air used in different chemical process (reaction and utility) is process air. The air should be dried and purified. **Instrument air:** It is used in instrumentation and tools. The air should be of required pressure, dried and free from any moisture, impurities and traces of oil. **Compressed air:** It is required for different purpose in chemical industries. It is used in chemical processes,, to avoid any side reactions, the air is dried and purified.	4	4
3	**Attempt ant four**		16
3-a	**Vapour compression refrigeration cycle:** The vapor-compression uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere. Figure shows a typical, single-stage vapor-compression system. All such systems have four components: compressor, condenser, thermal expansion valve, and an evaporator. Circulating refrigerant enters the compressor and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed vapor is then in the thermodynamic state known as a superheated vapor and it is at a temperature and pressure at which it can be condensed with either cooling water or cooling air. That hot vapor is routed through a condenser where it is cooled and	2	4

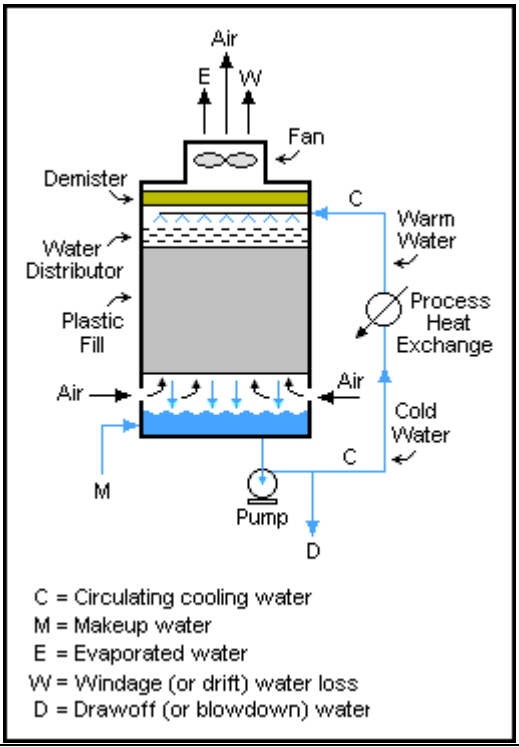
	condensed into a liquid by flowing through a coil or tubes with cool water or cool air flowing across the coil or tubes. This is where the circulating refrigerant rejects heat from the system and the rejected heat is carried away by either the water or the air The condensed liquid refrigerant next routed through an expansion valve where it undergoes an abrupt reduction in pressure. The cold mixture is then routed through the coil or tubes in the evaporator. A fan circulates the warm air in the enclosed space across the coil or tubes carrying the cold refrigerant liquid and vapor mixture. That warm air evaporates the liquid part of the cold refrigerant mixture. At the same time, the circulating air is cooled and thus lowers the temperature of the enclosed space to the desired temperature. The evaporator is where the circulating refrigerant absorbs and removes heat which is subsequently rejected in the condenser and transferred elsewhere by the water or air used in the condenser. To complete the refrigeration cycle, the refrigerant vapor from the evaporator is again a saturated vapor and is routed back into the compressor.		



2

3-b IBR and Non IBR BOILERS: 4 4

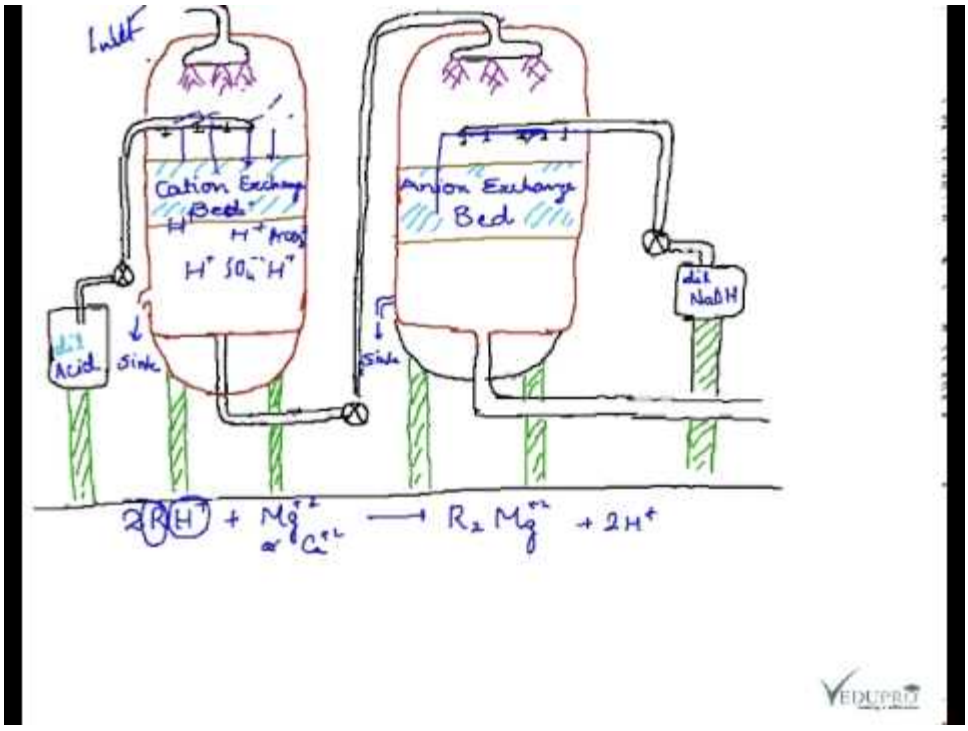
IBR boiler	Non IBR boiler
i)It should be register	i)need not registered
ii)registration should be renew after expiry.	ii)no need to renew
iii)the chief inspector will inspect boiler and accessories, its size when it is new.	iii)no need to inspect
iv)permission must be taken from against chief inspector when boiler transfer from one state to another.	iv) not need permission for transfer

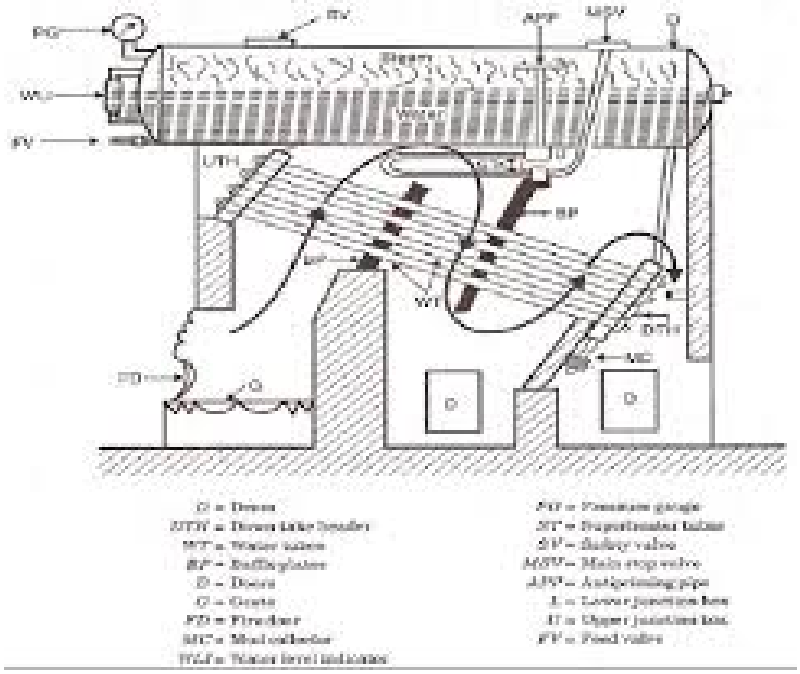
	v) e.g. Cochran boiler, Wilcox Babcock boiler etc.	v) e.g. boilers or steam pipes used in army, navy or air force and railways	
3-c	COOLING TOWER:  C = Circulating cooling water M = Makeup water E = Evaporated water W = Windage (or drift) water loss D = Drawoff (or blowdown) water	4	4
3-d		2 marks each	4

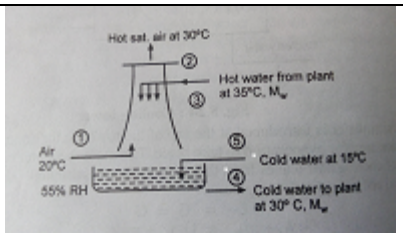
humidification	dehumidification
i)if unsaturated air is passed through a spray of continuously recirculated water the specific humidity will increase while the dry	i)The process in which the moisture or water vapor or the humidity is removed from the air keeping its dry bulb (DB) temperature constant is called

	bulb temp. decrease .this is the process of adiabatic saturation or evaporative cooling. ii)If water is added to air without any heat supply the state of air changes adiabatic along a constant enthalpy line - *h - in the Mollier or psychrometric chart*. The dry temperature of the air decreases. .	as the dehumidification process. Ii)This process is represented by a straight vertical line on the psychrometric charts starting from the initial value of relative humidity, extending downwards and ending at the final value of the relative humidity. Like the pure humidification process, in actual practice the pure dehumidification			
3-e	**Application of air in industry:** i)Cleaning automobiles and workshops. ii) Starting I.C. engine. iii) Spraying fuel in high speed diesel engine. iv)Spraying paints in paint industry. v)Construction of bridges, roads, dams, structural work , sewage and tunnels. vi) Cooling of large buildings. vii)Operation of pneumatic drills, wrenches, air motors, hammers, also for riveting and tightening nuts etc. viii) Supercharging I.C. engine and in working of gas turbine plants			½ marks each	4

3-f	**Boiler mountings:** i)safety valves ii)water level indicator iii)feed check valve iv)steam stop valve v)blow off cock **Boiler accessories:** i)air preheater ii)economizer ii) super heater iv)feed pump v)steam injector.	2 2	4
4 a	**Attempt ant four**		16
4-a	**Ion exchange method:** There is two types of ion exchangers in ion exchange method: i)cation exchange resin ii)anion exchange resin i)cation exchange resin: these are capable of exchanging cations in water by H^+ ions. Their exchange reaction are: $RH_2 + Ca^{++} \rightarrow RCa + 2\ H^+$ These cation exchanges when exhausted can be regenerated by passing through their bed of strong acid solution. ii) anion exchange resin: these are capable of exchanging anion in water by	2	4

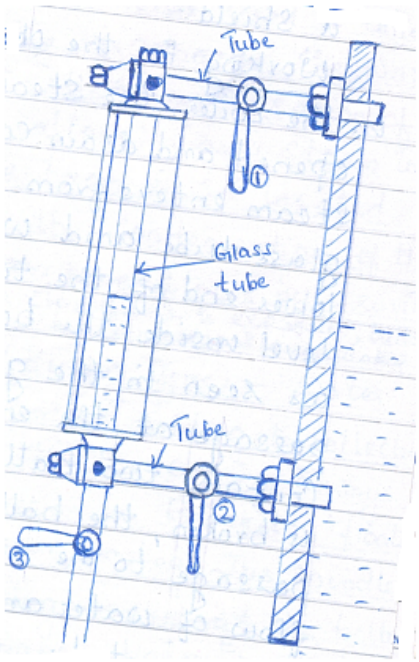
	hydraulic ion. The functional group in anion exchanger –OH group are stable and react fast. there exchanger reaction are: $R`(OH)_2 + SO_4 \rightarrow R`SO_4 + 2\ OH$ When it exhausted can be regenerated by passing through their bed of strong alkalies solution $R`SO_4 + 2\ NaOH \rightarrow R`(OH)_2 + Na2SO_4$  	2	

4-b		4	4
4-c	**Properties of ideal refrigerants:** i)The boiling point should be low. ii)Condensation pressure should not be more. iii)Critical temp. should be low. iv)The latent heat of vaporization should be low. v)specific heat of liquid should be low. vi)it should not have any corrosive action with system materials. vii)it should be nonflammable and non-explosive viii)it should be non-toxic	½ marks each	4
4-d	Spray ponds:	4	4

	 A spray pond is a reservoir in which warmed water (e.g. from a power plant) is cooled before reuse. This is done by spraying the warm water with nozzles into the cooler air. Evaporation cools the water down before it reaches the pond surface. The spray pond is the predecessor to the natural draft cooling towers, which is much more efficient and takes up less space but has a much higher construction cost. A spray pond requires between 25 to 50 times the area of a cooling tower.		
4-e	**Thermic fluid is used instead of steam because,** i) Thermal mediums offer high temperature operation capabilities (synthetic oils can be heated up to 800F) yet remain at low pressures. ii) The risks of scale formation, corrosion and frost are also avoidable for oil based heat transfer media. iii) Thermal fluid heaters are easier that common steam systems to operate and maintain. iv) There are also many different types of heat recovery options that allow our thermal fluid heater to operate at optimal efficiency.	1 mark each	4
4-f	Given: T1 = 30 = 30 +273 = 303 K T2 = -1.0 = -10 +273 = 263		4

	C.O.P. = T2/(T1 – T2) = 263 / (303- 263) = 6.575 R.E. = 10 TON = 10 X 3.517 = 35.17 KJ/s POWER Required (W) = R.E. / (C.O.P.) = 35.17 / 6.575 = 5.349 KJ/s Ans: C.O.P = 6.575 Power required = 5.349 KJ/s	1 1 1 1	
5	**Attempt ant four**		16
5-a	**Classification of boiler:** 1.Use a. stationary b. mobile 2. Tube contents a. fire tube boiler b. water tube boiler 3. Tube shape and position a. Tube shape (Form) –i. Straight ii. Bent iii. sinuous b. Inclination(position) – i. horizontal ii. Inclined iii. Vertical 4. furnace position a. Externally fired boiler b. Internally fired boiler	1 mark each for any 4	4

	5. Circulation a. natural circulation b. forced circulation 6. Heat source a. Fuel b. hot wastergaes c. electrical energy d. nuclear energy		
5-b	**Duties of boiler inspector**: 1.Confirm all boilers are registered. 2. Make sure that all boilers are working according to the act. 3. Check and examine boilers, their parts and mountings etc. 4. Advise the employer of boiler regarding the matters of boiler maintenance, cleaning and upkeep.	1 mark each	4
5-c	**Water level indicator** **Construction:**Water level indicator indicates the level of water in the boiler drum and warns the operator if by chance the water level goes below a fixed mark so that corrective action may be taken in time to avoid any accident. It consists of three cocks and a glass tube. The steam cock 1 keeps the glass tube in connection with the steam space and cock 2 puts the glass tube in connection with the water space in the boiler. The drain cock 3 is used to drain out the water from the glass tube at intervals to ascertain that the steam and water cocks are clear in operation. **Working:** The steam and water cocks are opened and the drain coke is closed. The steam enters from the upper end of the glass tube and water enters from the lower end of the tube, so the water level inside the boiler will be the same as seen in the glass tube.	2 2	4

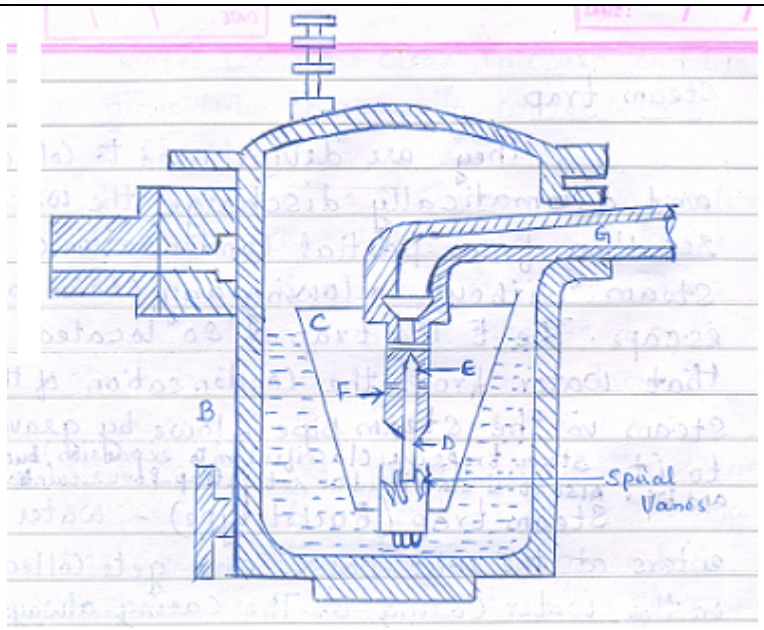
	 1- steam cock 2-water cock 3-draincock		
5-d	**(i)Scale and sludge formation:** When hard water is evaporated in boiler, the concentration of soluble salts of calcium and magnesium reaches saturation point and they are thrown out along with other soluble impurities in the form of precipitate. If the 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. **(ii)Priming and forming**: Priming 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 large quantities of dissolved organic oily matter, suspended	1 1 1	4

	material etc. Forming is the phenomenon of formation of foam or bubbles on surface of water which do not break easily.	1	
5-e	From steam table, corresponding to a pressure of 10 bar, Specific enthalpy of saturated water h_f = 762.6 KJ/ Kg Enthalpy of evaporation h_{fg} = 2013.6 KJ/ Kg Specific entropy of water S_f= 2.138 KJ/ KgK Entropy of evaporation S_{fg}= 4.445 KJ/ KgK Specific volume of steam = 0.19430 m^3 / Kg Enthalpy of steam = $h_f + h_{fg}$ = 762.6 + 2013.6 = **2776.2 KJ** Entropy of steam = $S_f + S_{fg}$ = 2.138 + 4.445 = **6.583 KJ /K** P = 10 bar = $10*10^5$ N / m^2 = 10^3 K N / m^2 Internal energy of steam = h- PV = 2776.2 - 10^3 * 0.1943 = **2581.9 KJ**	1 1 1 1	4
5-f	**Effects of impure boiler feed water:** 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 andNaOH flows into the minute hair cracks . In the cracks water evaporates and the caustic soda dissolves iron of	1 1	4

<table>
<tr><td></td><td>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.
4. Priming and forming: Priming 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 large quantities of dissolved organic oily matter, suspended material etc.
Forming is the phenomenon of formation of foam or bubbles on surface of water which do not break easily.</td><td>1

1</td><td></td></tr>
<tr><td>6</td><td>Attempt ant two</td><td></td><td>16</td></tr>
<tr><td>6-a</td><td><table>
<tr><td></td><td>Conventional methods</td><td rowspan="2">Advance method(membrane)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Cost</td><td>Low capital and operating costs</td><td>High capital and operating costs</td></tr>
<tr><td>Regeneration</td><td>Regeneration is easily done</td><td>Regeneration is time consuming and costly</td></tr>
</table></td><td>4 marks each</td><td>8</td></tr>
<tr><td>6-b</td><td>Selection criteria for refrigerant :</td><td>1 mark</td><td>8</td></tr>
</table>

	1. Working pressure range and pressure ratio. The pressure required to be maintained in the evaporator and condenser should be low enough to reduce the material cost and must be positive to avoid leakage of air into the system. 2. Corrosiveness and flammability: Non corrosive to mechanical components. It should be safe to operate(including non-toxic, nonflammable) 3. Space limitations: It should have low specific volume to reduce the size of the compressor. 4. Temperature required in the evaporator: It should have low boiling point and low freezing point. 5. Oil miscibility. It should have high miscibility with lubricating oil and it should not have reacting property with lubricants. 6. It should not have any bad effect on the stored material or food when any leak develops in the system. 7. It should have low thermal conductivity to reduce the area of heat transfer in the evaporator and condensers. 8. It should have high critical pressure and temperature to avoid large power requirement. **9.** It must have low specific heat and high latent heat. 10. It should have moderate density in liquid form, a relatively high density in gaseous form.	each for any 8	
6-c	**Bucket type steam trap:** **Importance of steam trap** They are used to collect and automatically discharge the water resulting from partial condensation of steam without allowing any steam to escape. **Diagram:**	3	8

	 B-casing C-bucket D- spindle E- Valve F- Seat G- exit pipe	5	