SUMMER-15 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
1a-i	**Impurities in hard water:** Impurities in hard water can be listed as follows. 1. Suspended impurities: They are dispersion of solid particles that are large enough to be removed by filtration or settling. The particles which are lighter than water like clay silt, algae etc float on the surface. 2. Dissolved inorganic impurities: They are impurities which are dissolved in water, when it moves over rock, soil etc. eg. Calcium and magnesium carbonates, sulphates, chlorides etc. 3.Organic impurities: they are suspended vegetable and dead animals and dissolved vegetable and animal products. 4.Bacterial impurities: Bacteria, micro organisms are disease causing germs present in water	2	2
1a-ii	**Hardness of water can be measured by:** 1. ppm(parts per million) 2. Milligrams/ litre 3. Clarke's degree 4. Degree French	1 mark each for any 2	2
1a-iii	**Primary refrigerants** : They are the safest refrigerants which passes through the cyclic process. **Secondary refrigerants:** They are the refrigerants which do not pass through the cyclic process.	1 1	2
1a-iv	**1)Enthalpy of water** : The amount of heat absorbed by 1 kg. of water to heat it from freezing point (0^oC) to the boiling point is known as enthalpy of saturated water.	1	2

	2) Enthalpy of evaporation It is the amount of heat required to convert one kilogram of water at a given temperature and pressure into steam at the same temperature and pressure.	1	
1a-v	**Dryness fraction** : The fraction of steam that is in the Vapour form is called dryness fraction of steam. If m_g is the mass dry steam per kg of mixture and m_f is the mass of liquid water per kg of mixture then dryness fraction $x=m_g/(m_g+m_f)$	1 1	2
1a-vi	**Specific humidity:**.It is the ratio of mass of water vapour to the mass of dry air present in air- water vapour mixture. **Relative humidity:** It is the ratio of mass of water vapour in air of given volume at a given temperature to the mass of water vapour in same volume at same temperature when air is saturated	1 1	2
1a-vii	**Advantage of thermic fluid over steam:** (1)High temperature can be obtained at moderate pressure (2) Have wide range of operation stability. (3) More economical at high temperature. (4) No pretreatment equipment is required when used in boiler (5) no heat loss (6) No risk of corrosion (7) Low maintenance cost (8) Quiet and easy to operate	1 mark each for any 2	2
1b-i	**Reactions take place in lime soda process:** $2HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O$ $H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$	1 mark each for any 4	4

	$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$ $Mg(HCO_3)_2 + 2\ Ca(OH)_2 \rightarrow 2CaCO_3 + Mg(OH)_2 + 2H_2O$ $MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaCl_2$ $MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaSO_4$ $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$ $CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 + Na_2SO_4$ $CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + 2H_2O$ $H_2S + Ca(OH)_2 \rightarrow CaS + 2H_2O$		
1b-ii	**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. **Value in SI:** 1 ton of refrigeration = 12660 kJ/hr = 3.517 kW	2 2	4
1b-iii	**Factors for boiler selection** : 1. The pressure at which boilers, is to operate and quality of steam required. 2. Rate of steam generation i.e. quantity of steam per hour required to be produced. 3. Availability of floor area. 4. Efficiency of boiler in same range. 5. Easy accessibility for cleaning, repairs and instructions. 6. Comparative initial cost. 7. Erection facility.	1 mark each for any 4	4
2-a		1 mark	4

Comparison of hot and cold lime soda process:

Cold lime soda process	Hot lime soda process
Treatment is done at room temperature	Treatment is done at a temperature of 80-100^{0}C
Chemical reactions are slower	Chemical reactions are faster
Large size storage tanks are essential	Less storage capacity tanks are required
Process requires more time	Requires less time
Coagulants are required	No coagulants are required
Soft water obtained contains 50-60 ppm of residual hardness	Soft water obtained contains 15-30 ppm of residual hardness

each for any 4

2-b

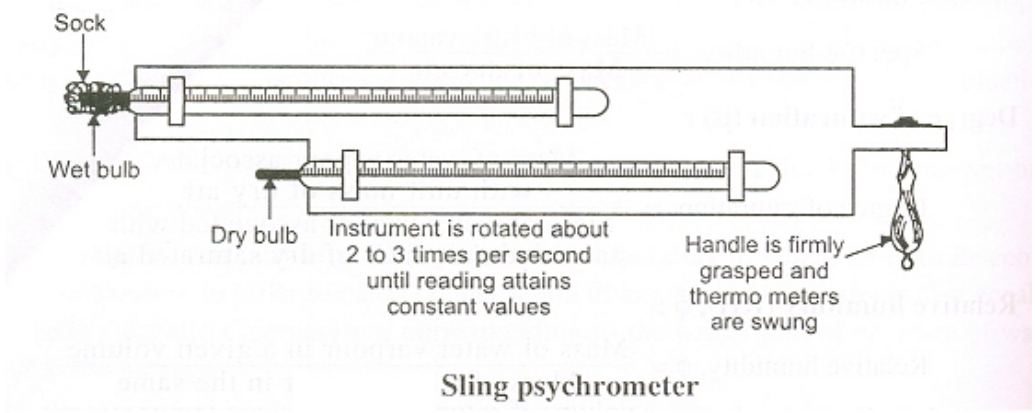
Safe working properties of ideal refrigerants:

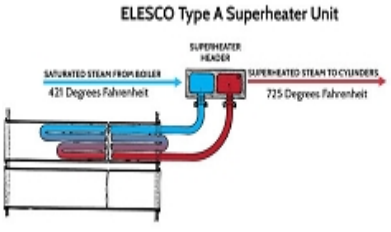
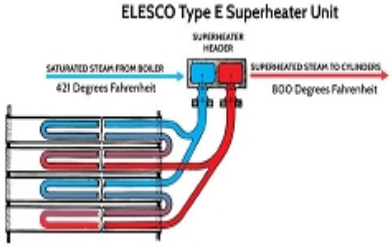
1. Non corrosive to mechanical components,
2. Safe (including nontoxic, nonflammable).
3. Boiling point somewhat below the target temperature.
4. High heat of vaporization.
5. Moderate density in liquid form, a relatively high density in gaseous form,
6. High critical temperature.
7. Chemically inert
8. Non Toxic
9. Non flammable
10. Non Corrosive

½ mark each for any 8

4

	11. Chemically stable. 12.. It should operate under low pressure 13. It should have a well balanced enthalpy of vaporization per unit mass. 14. A minimum difference between the vaporizing pressure and condensing pressure is desirable.		
2-c	**Advantages of Water tube boiler:** 1. Water tube boilers generate steam of high pressure 2. They raise steam quickly. 3. Heating surface is much more effective. 4. The direction of water tube boiler is well defined. The circulation is rapid all over the boiler, keeping the boiler at a nearly constant temperature. 5. Flexible construction. 6. Easy to transport 7. Accident free. **Disadvantages of water tube boiler:** 1. Less suitable for use with impure and dirty water. 2. Require expert attention 3. Cost is high **4.** More difficult to inspect.	1mark each for any 2 1mark each for any 2	4

2-d	 Sling psychrometer Sling psychrometer consist of two thermometers mounted on base plate. The one with the sock is wet bulb thermometer and the other is dry bulb. The handle of the frame helps for rotating the psychrometer to produce necessary air motion. As the psychrometer is rotated , it provides necessary air velocity over the thermometer. The temperature spread between dry bulb and wet bulb readings depends upon the amount of moisture in the air.	2 2	4
2-e	**Uses of process air:** 1. In the oxidation of acetaldehyde to acetic acid 2. Oxidation of NO to NO_2 in manufacture of HNO_3 3. In H_2SO_4 manufacture 4. In spray painting 5. In furnace 6. In refrigeration system 7. In boiler 8. In petroleum refining and petrochemical process	1 mark each for any 4	4
2-f	**Impurities of water which causes corrosion in boiler:** 1. Dissolve oxygen 2. Dissolved Carbon dioxide, H_2S	2	4

	3. Chlorides of Calcium and Magnesium **Prevention of corrosion:** 1. Mechanical de aeration 2. Chemical degasification	2	
3-a	**Eco friendly refrigerant:** The eco friendly refrigerant would have favourable thermodynamic properties. Be noncorrosive to mechanical components, and be safe, including free from toxicity and flammability. It would not cause ozone depletion or climate change. The desired thermodynamic properties are a boiling point somewhat below the target temperature. e.g. Lithium bromide - water Refrigerants such as ammonia (R717), carbon dioxide and non-halogenated hydrocarbons do not deplete the ozone layer and have no (ammonia) or only a low (carbon dioxide, hydrocarbons) global warming potential.	2 2	4
3-b	**Super heater:**   **Working:**	2	4

	superheater header mounted against the tube sheet in the smoke box.The steam is then passed through a number of superheater elements—long pipes which are placed inside special, widened fire tubes, called flues. Hot combustion gases from the locomotive's fire pass through these flues just like they do the fire tubes, and as well as heating the water they also heat the steam inside the super heater elements they flow over. The super heater element doubles back on itself so that the heated steam can return; most do this twice at the fire end and once at the smoke box end, so that the steam travels a distance of four times the header's length while being heated. The superheated steam, at the end of its journey through the elements, passes into a separate compartment of the super heater header and then to the cylinders as normal.	2	
3-c	Given : WBT = 22 DBT = 30 From psychometric chart, Find the intersection of 30 deg C DBT and 22 deg C WBT and move horizontally to the dew point temp scale. Dew point temp. = 18.6 ^{o} C Absolute humidity = 0.016-0.018 Kg/kg dry air	1 1 2	4
3-d	**Forced draft cooling tower:**		4

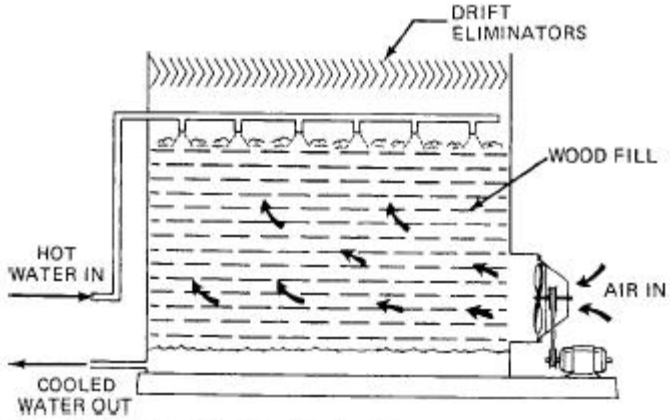


Figure 8-17 Forced-draft cooling tower.

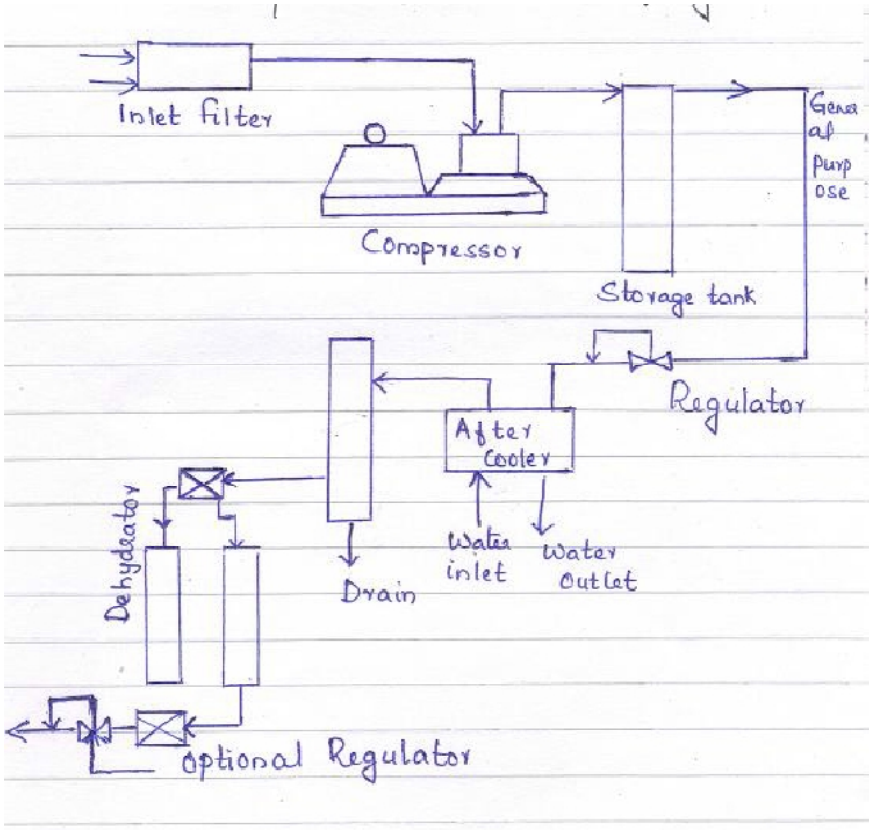
2

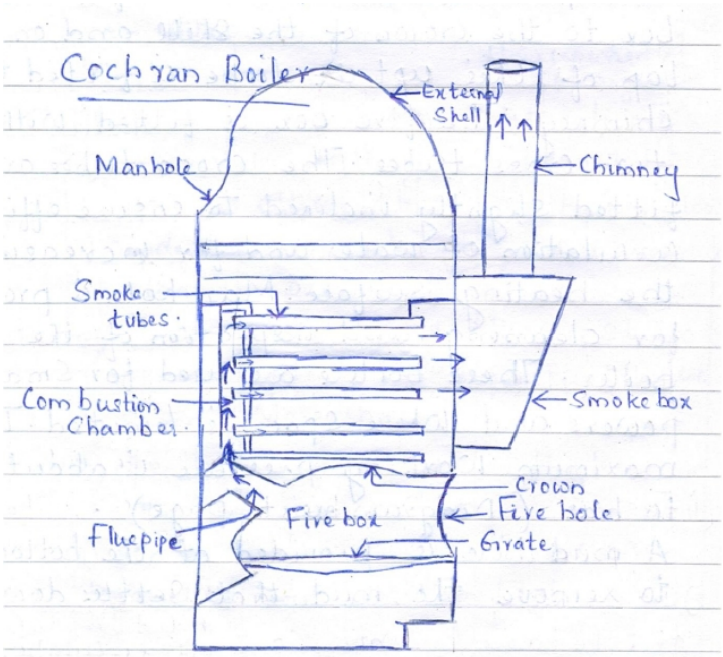
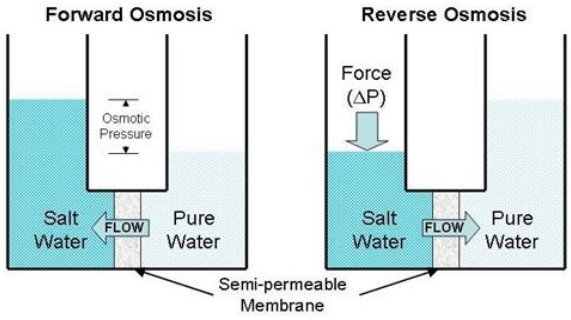
Construction and working:

2

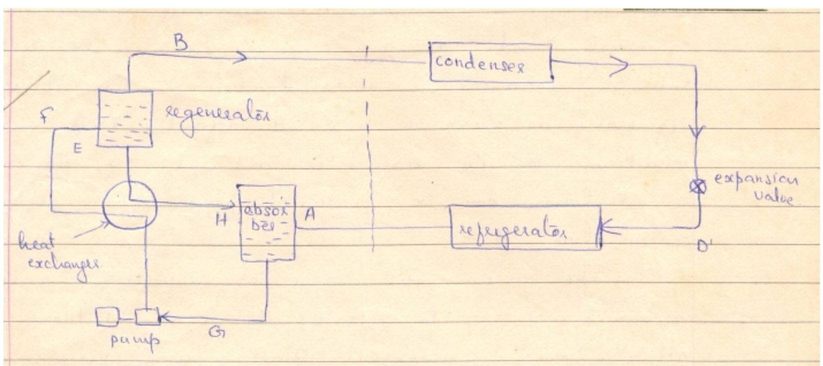
A cooling tower is a heat rejection device which rejects waste heat to the atmosphere through the cooling of a water stream to a lower temperature. Cooling towers may either use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature or, in the case of *closed circuit dry cooling towers*, rely solely on air to cool the working fluid to near the dry-bulb air temperature.

Forced draught — A mechanical draft tower with a blower type fan at the intake. The fan *forces* air into the tower, creating high entering and low exiting air velocities. The low exiting velocity is much more susceptible to recirculation. With the fan on the air intake, the fan is more susceptible to complications due to freezing conditions. Another disadvantage is that a forced draft design typically requires more motor horsepower than an equivalent induced draft design. The benefit of the forced draft design is its ability to work with high static pressure . Such setups can be installed in more-confined spaces and even in some

	indoor situations. This fan/fill geometry is also known as *blow-through*.		
3-e	**Process of getting 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

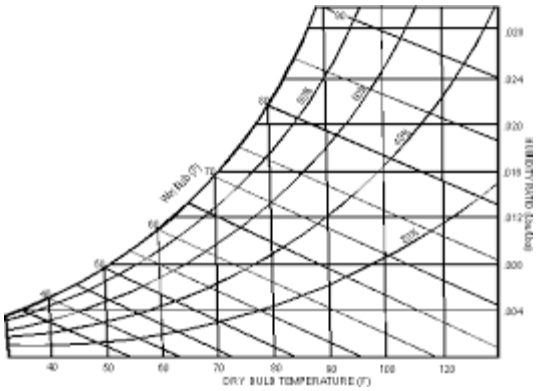
	constant reduced pressure in the supply line		
3-f	**Cochran Boiler** 	4	4
4-a	**Reverse osmosis:**  **Description:** It is the process of filtration. In this , we take water with salt in it , an apply pressure to it against a certain type of membrane and presto out comes clean water.	2 2	4

	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. 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		

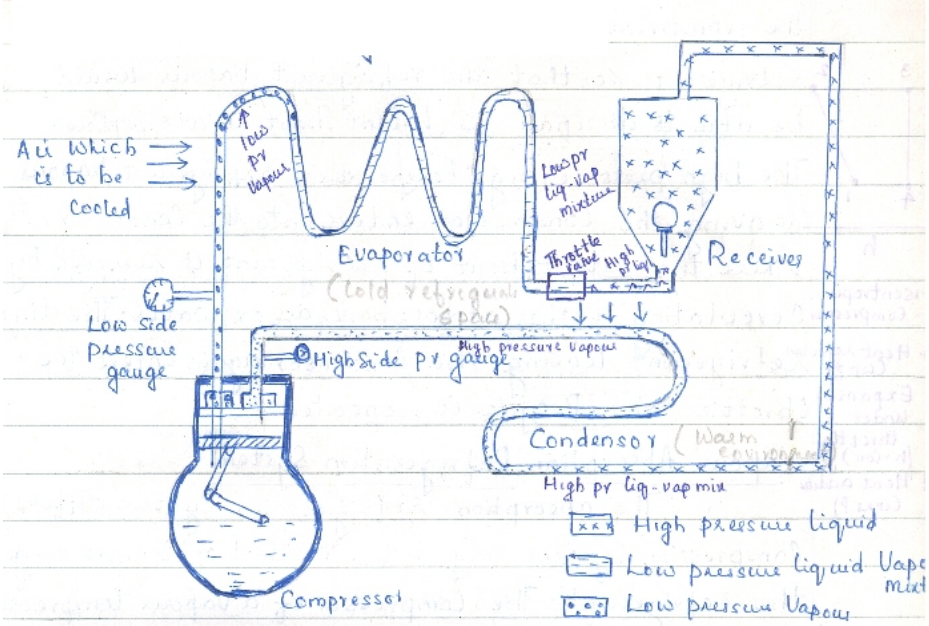
<table>
<tr><td></td><td>than the osmotic pressure.</td><td></td><td></td></tr>
<tr><td>4-b</td><td>Vapour Absorption system
 

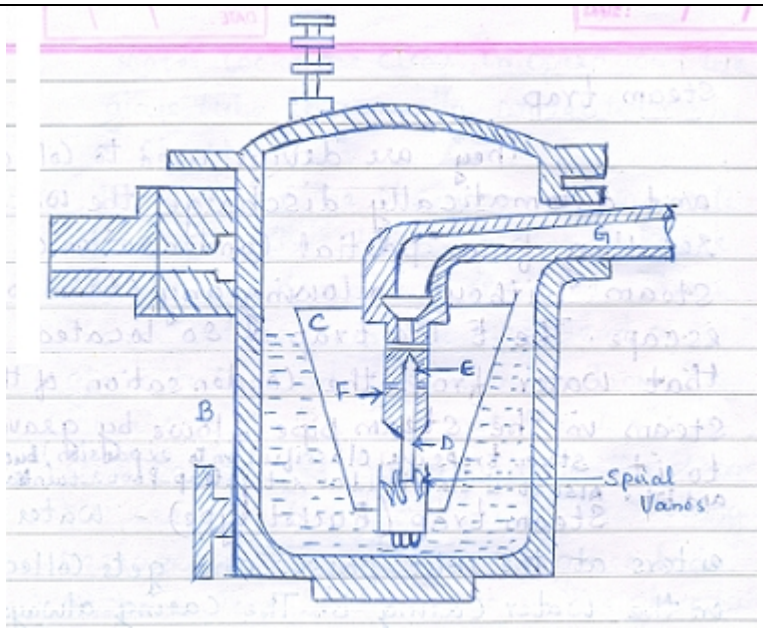
In absorption system the compressor in the vapor compression cycle is replaced by an absorber- generator assembly involving less mechanical work. Ammonia is the refrigerant and water is the absorbent. Ammonia vapor is vigorously absorbed in water. So low pressure ammonia vapor from the evaporator comes 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 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.</td><td>2

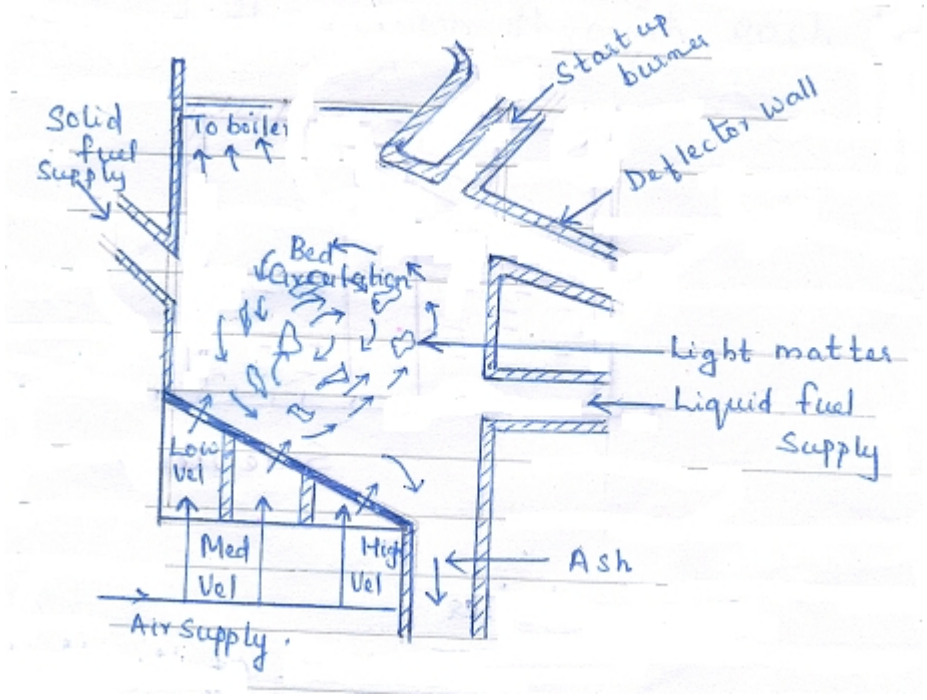
2</td><td>4</td></tr>
</table>

4-c	**Boiler mountings:** They are equipment mounted on boiler for the safe working of boiler. Different boiler mountings are: Water gauge or water level indicator Pressure gauge Fusible plug Lever safety valve **Uses:** Water Level Indicator : it is used to indicate the level of water in the boiler constantly. Fusible plug : It is used to protect the fire box crown plate or the fire tube from burning when the level of the water in the water shell falls abnormally low. Pressure gauge: To indicate the pressure inside the boiler. Safety vale: To release the excess steam to maintain the pressure.	2 1mark each for any 2	4
4-d	**Construction of psychometric 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.	4	4

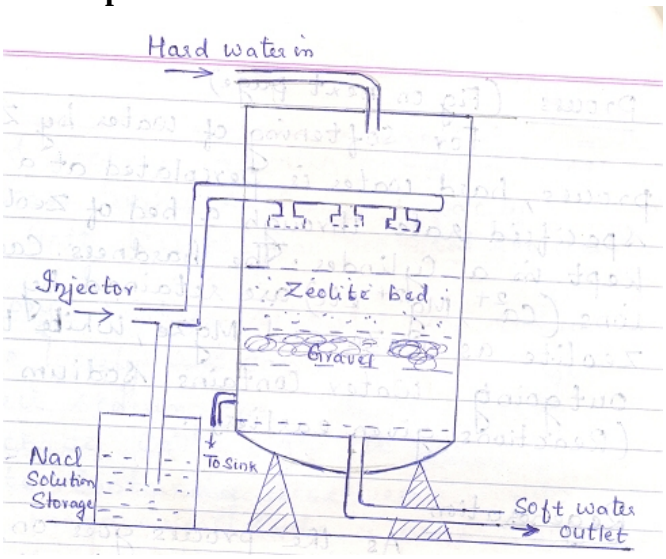
	Pressure of water vapour in mm of Hg is shown in the scale at left and is the absolute pressure of steam. Dew point temp. Re shown in the scale on the upper curved line. Constant RH Lines in per cent are indicated by marking off vertical distances between the saturation line or the upper curved lines and the base of the chart.		
4-e	**Dowtherm – A:** This fluid is an organic compound of high heat stability , a eutectic mixture containing 73.5 per cent diphenyl oxide and 26.5 per cent diphenyl by weight. At its freezing point of 54 deg F Dowtherm A contract slightly, thereby removing the possibility of damage to process equipment when shut down under cold weather condition. at room temp , it is clear , almost colourless liquid , which darkens rapidly in use without change in physical characteristics. It does not react chemically with metal.	4	4
4-f	Given: Highest temp. T1 = 35 = 308 K Lowest temp. T2 = - 15 = 258 K C.O.P = T2/ (T1 – T2) = 258 / (308 – 258) = 5.16	 1 2 1	4
5-a	**Vapour compression refrigeration system:** **Diagram:**		4

	 **Description:** The liquid coming out from the condenser is passed through the throttle valve. The pressure of the refrigerant is reduced as it passes through the throttle valve. A mixture of vapour and liquid refrigerant enters the evaporator at low pressure. The liquid refrigerant absorbs the heat load on the refrigerator as its latent heat of evaporation and gets converted into vapour. The function of the compressor is to increase the pressure of the refrigerant so that the refrigerant vapour would be able to dissipate its latent heat to atmosphere. The high pressure, high temperature refrigerant vapour leaving the compressor enters into the condenser where the latent heat of refrigerant is removed by circulating either atmospheric air or water. The liquid refrigerant leaving the condenser again enters the throttle valve and the cycle is repeated.	2 2	
5-b	**Bucket type steam trap:** **Diagram:**		4

	 B-casing C-bucket D- spindle E- Valve F- Seat G- exit pipe **Use:** They are used to collect and automatically discharge the water resulting from partial condensation of steam without allowing any steam to escape.	2 2	
5-c	**Fluidized bed boiler:** In fluidized bed boiler, coal upto 12mm size can be burned while they are suspended in an agitated state within the combustor, using air blown in from the bottom. Fuels like bagasse rice husk, paper sludge, etc can be used. The major problem with the coal fired boilers containing high sulphur is to suppress the So_2 formed before exhausting the gas into the atmosphere as it is highly poisonous to human health & crops. The FBB permits the injunction of limestone directly into the furnace which can easily capture So_2. This eliminates the need for expensive flue gas scrubbing system downstream of the boiler.	2	4

		2	
5-d	**Dry bulb temperature:** Temperature recorded by ordinary thermometer is called dry bulb temperature. **Dew point temperature:** It is the temperature of air at which water vapour in air starts condensing.	2 2	4
5-e	From the conditions given, it is **wet steam** From the steam table, corresponding to a pressure of 5 bar, **Enthalpy of water** =640.1KJ / Kg	2 2	4
5-f	**Comparison of zeolite process and ion exchange process:**	1mark each	4

Zeolite Process	Ion exchange process
1. Zeolite is hydrated sodium alumino silicate	Ion exchange resins are cross linked long chain organic polymers
2. Sodum ions are exchanged for hardness producing ions	Functional groups(acidic and basic) in the resins are exchanged for cations and anions in water

	3. Only hardness producing ions are removed.	All cations and anions are removed	
	4 Treated water is known as soft water	Treated water is known as demineralised water.	
6-a	**Zeolite process**  Zeolites are hydrated sodium alumino silicates, capable of exchanging reversibly their sodium ions with hardness producing ions in water These silicates hold sodium ions loosely and can easily exchange their sodium ions with other cations such as Ca^{2+} , Mg^{2+} For softening of water by Zeolite process, hard water is percolated at a specified rate through a bed of zeolite, kept in a cylinder. The hardness causing ions (Mg^{2+},Ca^{2+} etc) are retained by the zeolite as CaZe and MgZe, while the outgoing water contain sodium salts. $CaCl_2$(or $CaSO_4$) + $Na_2Ze \rightarrow CaZe + 2NaCl$(or Na_2SO_4) $MgSO_4$ (or $MgCl_2$) + $Na_2Ze \rightarrow MgZe + 2NaCl$(or Na_2SO_4) $Ca(HCO_3)_2$ (or $Mg(HCO_3)_2$ + $Na_2Ze \rightarrow CaZe$ (or MgZe) + 2 $NaHCO_3$	3 3 2	8
6-b	**Important refrigerants used in industry:**		8

	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	3	
	R-22 is monochlorodifluoromethane(CHClF2) or Freon-22	2	
	Properties of R-22: 1. Stable 2. Non toxic 3. Non corrosive 4. Non irritating 5. Non inflammable 6. Boiling point 0f -40.80C at atmospheric pressure Good solubility in oil up to -10^0C	3	
6-c	T = 50^oc P = 13 bar From steam table at 13 bar Enthalpy of saturated water (h_f) = 814.7 KJ / Kg Enthalpy of evaporation (h_{fg}) = 1970.7 KJ / Kg	2	8
	(i) Steam produced is 0.9 dry x= 0.9 Enthalpy of 1 kg of wet steam at 13 bar = $h_f + xh_{fg}$ = 814.7 + (0.9 * 1970.7)	1	

	= 2588.33 KJ / Kg		
	Enthalpy of 1 Kg of feed water at 50^{o}c = mCp Δ T= 1* 4.187*(50-0)	1	
	= 209.35 KJ / Kg		
	Heat required to convert 1 kg of feed water at 50^{o}c into wet steam at 13 bar		
	= Enthalpy of wet steam – enthalpy of feed water		
	= 2588.33- 209.35 = **2378.98 KJ /Kg**	1	
	(ii) Dry saturated steam		
	Enthalpy of 1 kg of steam at 13 bar = h_f + h_{fg}		
	= 814.7 + 1970.7		
	= 2785.4 KJ / Kg	1	
	Enthalpy of 1 Kg of feed water at 50^{o}c = mCp Δ T= 1* 4.187*(50-0)		
	= 209.35 KJ / Kg	1	
	Heat required to convert 1 kg of feed water at 50^{o}c into steam at 13 bar		
	= Enthalpy of steam – enthalpy of feed water		
	= 2785.4- 209.35 = **2576.05** KJ/ Kg	1	