SUMMER-14 EXAMINATION

Model Answer

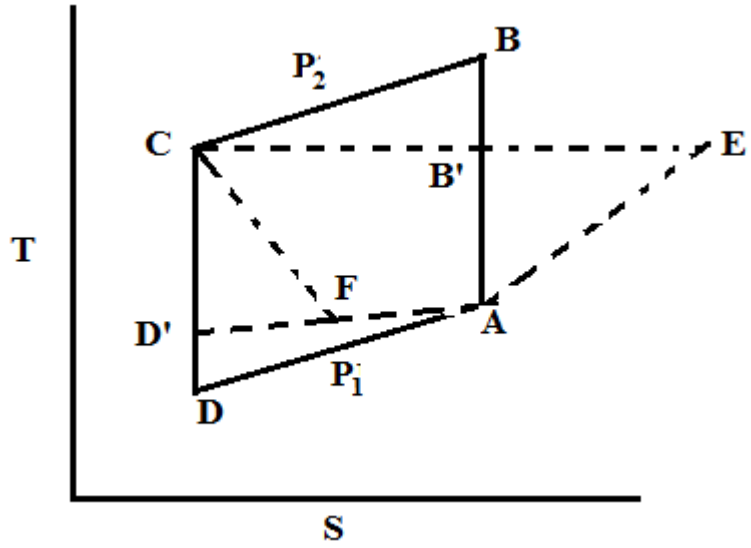
Important Instructions to examiners:

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.

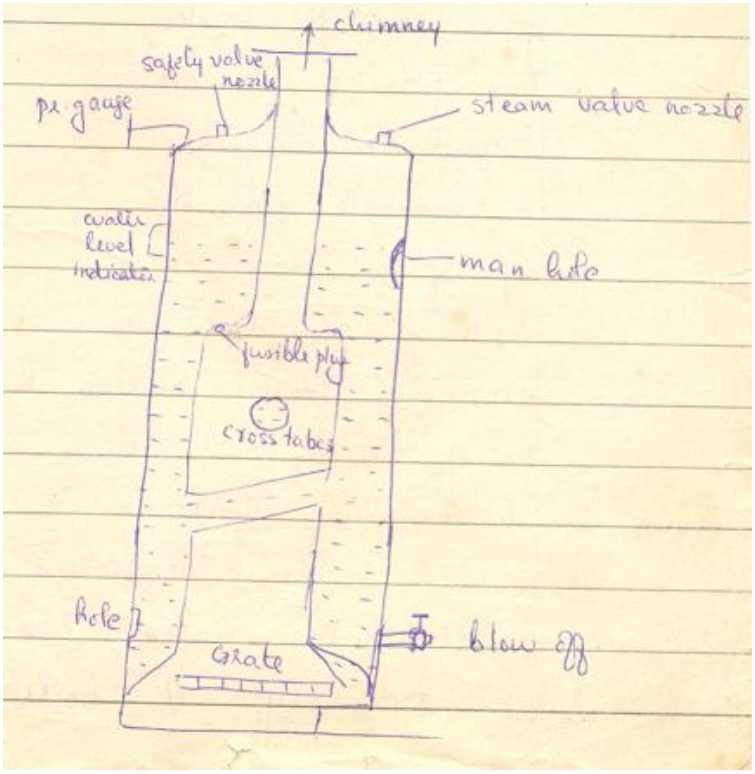
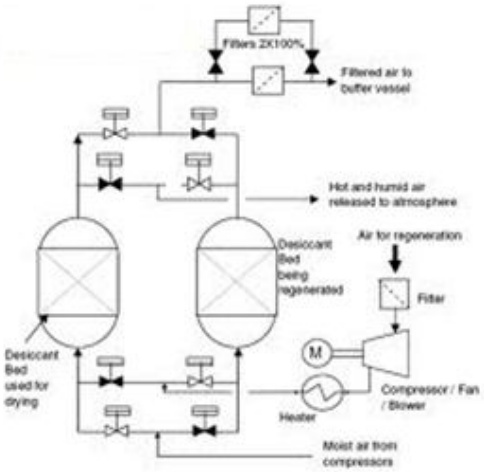
Q No.	Answer	marks	Total marks
1a-i	**Hard water** : Water containing dissolved salts of calcium and magnesium is called hard water. Due to the present of these salts, hard water can not produced good lather or foam with soap. **Soft water** : Water which does not contain any of the calcium and magnesium salts dissolved in it is called soft water. Soft water forms good lather with soap.	1 1	2
1a-ii	**Sensible heat** : It is the heat required to change the temperature of any substance .It can be calculated by $Q=mC_p\Delta T$ **Latent heat** : It is the heat required to change the phase of any substance at constant temperature . It can be calculated by $Q=m\lambda$	1 1	2
1a-iii	**Reason for scaling in boiler** : When hard water is evaporated in boiler , the soluble salts of calcium and magnesium along with other soluble impurities comes out in the form of residue. This residue settles in side the boiler and it called a scale.	2	2
1a-iv	**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.	½ mark each for any 4	2

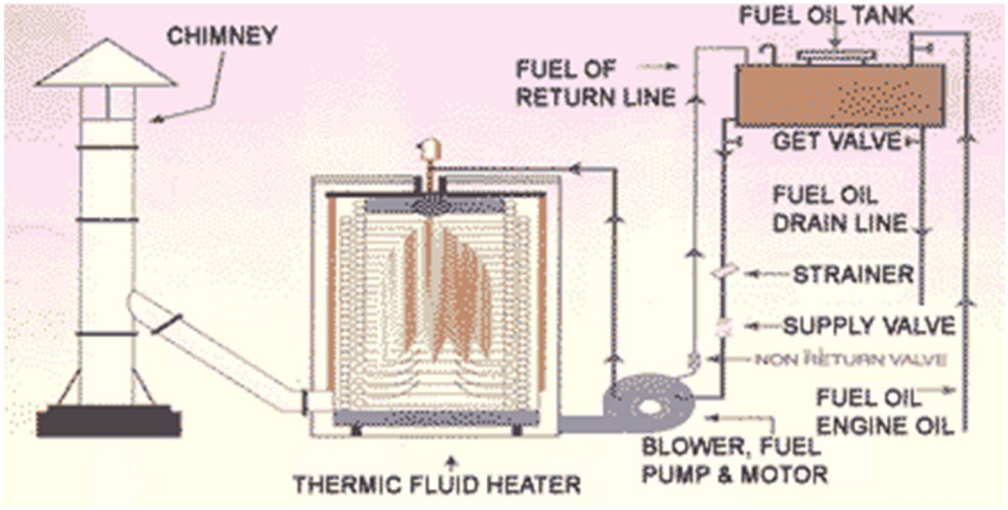
	5. Easy accessibility for cleaning , repairs and instructions. 6. Comparative initial cost. 7. Erection facility.		
1a-v	**Different refrigeration systems are** : 1. Air refrigeration(Bell-Coleman refrigeration) 2. Vapour compression refrigeration. 3. Vapour absorption refrigeration.	2	2
1a-vi	**Compressed air** : High pressure air obtained from a compressor is known as compressed air. 1. Compressed air is used in instrumentation purpose . 2. It is also used in chemical process such as oxidation etc.	1 mark each	2
1a-vii	**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
1b-i	**Classification of boiler** : 1. Use: Primarily the boilers are either stationary or mobile. 2. Tube content: In this category fall the two types of boiler, fire tube and water tube. In fire tube boiler, contents of the tubes are hot gases. In water tube boiler the contents of the tube are water or steam. 3. Tube shape and position: The tubular heating surface may be classified as 1. By straight. 2. By inclination. 4. Furnace position: According to the position of furnace the boilers are classified as externally fired or internally fired. A boiler is said to be externally fired when combustion take place out side the region of	1 mark each for any 4	4

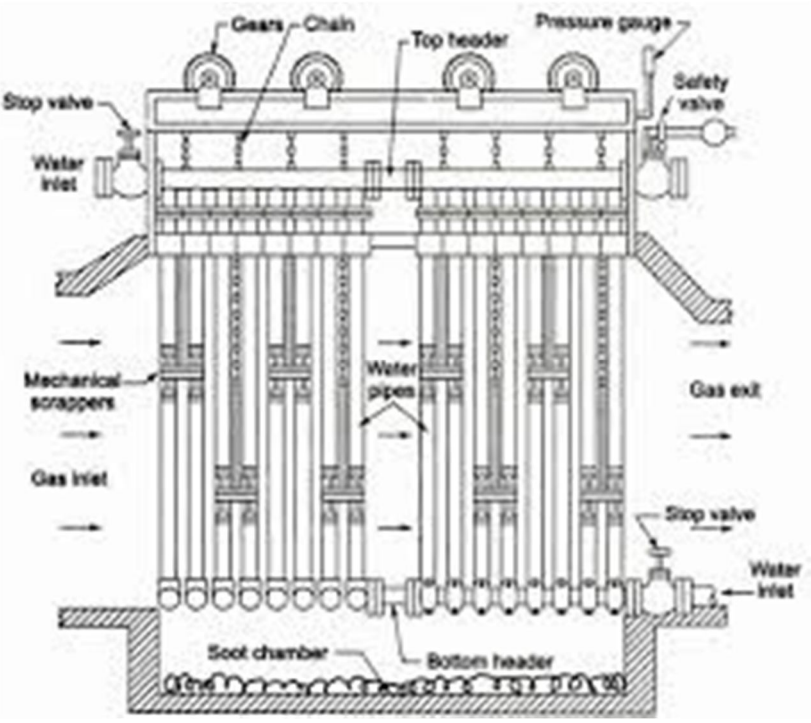
	boiling water. The boiler is said to be internally fired if the furnace region is completely surrounded by water cooled surface. 5. Heat source: Heat source may be combustion of fuel , hot waste gases , electrical energy or nuclear energy. 6. Circulation: Based on circulation boilers are natural circulation or forced circulation.		
1b-ii	**Carnot refrigeration cycle** : The ideal refrigeration cycle is that of Carnot consisting of two isothermal process in which Q_2 , the heat absorbed at lower temperature T_2 , and Q_1 the heat rejected at higher temperature T_1 and two adiabatic process, the result of which is the addition of the net work W to the system. Since change in internal energy of the fluid is 0 for the entire cycle, the first law of thermodynamics gives . $W= Q_1- Q_2$ $Q_1 = T_1\Delta S$ $Q_2= T_2\Delta S$ $Q=\Delta E+W$ Combining these equation we get $W/Q_1 = (T_1 – T_2)/T_1$ $W/Q_2 = (T_1 – T_2)/T_2$ From which work required for a given quantity refrigeration Q_2 may be computed.	4	4

	 Depicting another cycle ABCD operation in such a way that the temperature raises during heat absorption step and falls when heat is rejected. If the temperature of refrigerator is to be less than T_A and that of the condenser not less than T_C , the Carnot cycle will be AB'CD. The new cycle ABCD would have to operate in such a manner that the temperature of the fluid entering the refrigerator would be T_D so that it will not increase to a value higher than T_A when fluid leaves the refrigerator. This new cycle would then be operating at and average temperature less than that of the carnot cycle and it would be less efficient. Similarly , the maximum efficiency during heat rejection steps would be for isothermal process B'C corresponding to the carnot cycle and not process BC of the new cycle.		
1b-iii	**Zeolite process :** Zeolite process is used to treat hard water. Hard water is percolated at a specified rate through a bed of zeolite, kept in a cylinder. The hardness causing ions(Ca^{2+} , Mg^{2+} etc) are retained by the zeolite as CaZe and MgZe, while the outgoing water contains sodium salts.	2	4

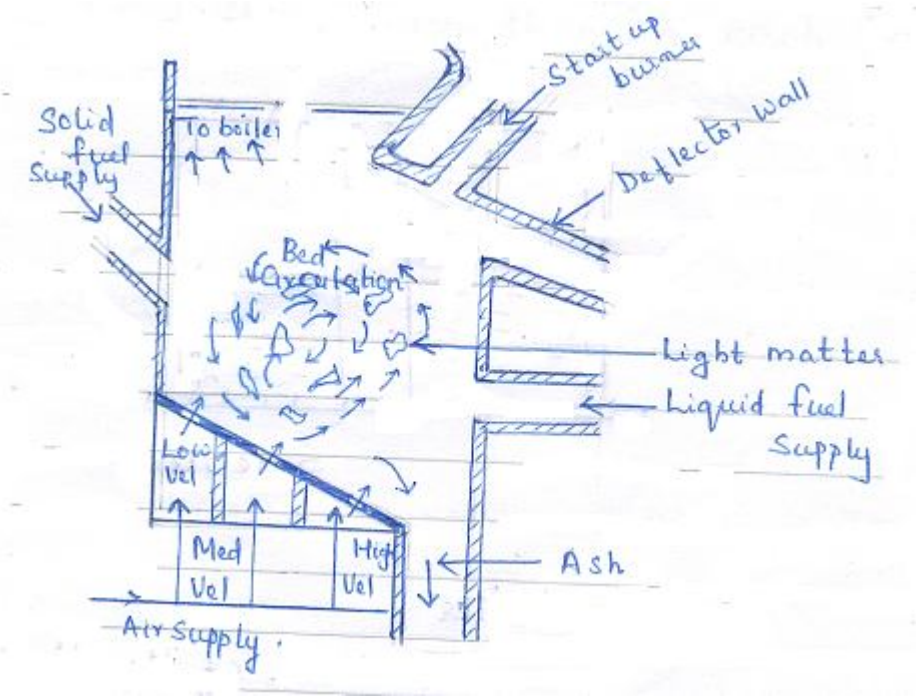
	Reactions are $CaCl_2$ (or Ca SO_4) + Na_2Ze → CaZe + 2NaCl (or Na_2SO_4) $MgSO_4$ (or $MgCl_2$) + Na_2Ze → MgZe + Na_2SO_4 (or 2NaCl) Ca $(HCO_3)_2$ (or Mg $(HCO_3)_2$) + Na_2Ze → CaZe (or MgZe) +2 $NaHCO_3$ **Advantages** : 1. Hardness is completely removed , the residual hardness is at about 10ppm. 2. Equipment used is compact and simple. 3. Suitable for all types of hard water. 4. Requires less time for softening. 5. Low cost 6. No precipitate is formed hence no problem of sludge formation and removal.	½ mark each for any 4	
2-a	**Selection criteria for refrigerant** : 1. Working pressure range and pressure ratio . 2. Corrosiveness and flammability. 3. Space limitations. 4. Temperature required in the evaporator 5. Oil miscibility.	1 mark each for any 4	4

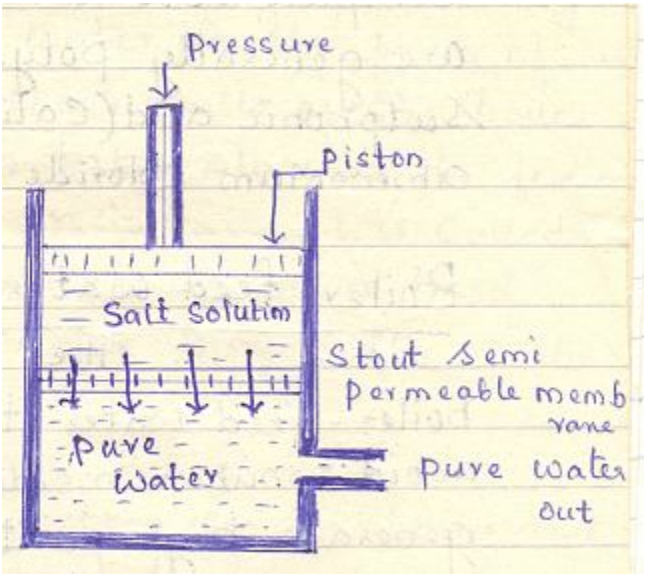
2-b	**Simple vertical boiler** : 	4	4
2-c	**Instrument air** 	2	4

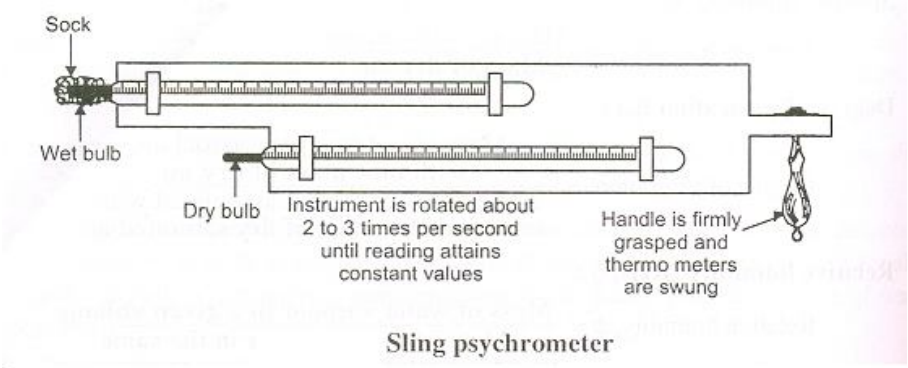
	Description An inlet filter removes all impurities from air and is then fed to a compressor where it is compressed. The compressed air is then passed into a storage tank from where to a pressure regulator and then to a water cooler. A stone filter removes oil and dehydrate completely. A second pressure regulator is sometimes added to provide a constant reduced pressure.	2	
2-d	**Thermic fluid heater:** It is the heater where thermic fluid is used. **Working** From fuel tank the oil goes to a fuel filter then into a fuel pump. Through the fuel pump it is passed into an electrically heated oil pre-heated tank and then forced to burner. The thermic fluid heater is supplied with pressure-jet burner of highly compact rugged and simple design. The burner is fully automatic in operation and switches ON and OFF as per the process heat requirements.  	1 1 2	4

2-e	**Economiser**  **Working** : Function of economizer is to recover some of the heat from the heat carried away in the flue gases up the chimney and utilized for heating the feed water to the boiler. From the water inlet water goes to be bottom boxes and raises up in the vertical pipes into the top boxes. From the top boxes it goes to the pipe from where it goes to be water space of boiler. Flue gas passes perpendicular to the tubes.	2 2	4
2-f	T_1=28+273=301K T_2= -5+273=268K COP = $T_2/(T_1-T_2)$ =268/(301-268) =8.12	1 1 2	4

3-a	**Classification of refrigerants:** A. National Refrigeration Safety Code, USA classifies all the refrigerants into 3 groups 1.Group 1 refrigerants (safest) 2. Group2 refrigerants (toxic and somewhat inflammable) 3. Group3 refrigerants (Inflammable refrigerants) B. National board of Fire Underwriters USA classifies refrigerants on the basis of their toxicity. There are six divisions on this scale. Class 1 is the most toxic and class 6 is least toxic C. Refrigerants are also classified as Primary refrigerants and secondary refrigerants.	4	4
3-b	**Boiler mountings** They are devices mounted on the boiler which are essential for the safe working of the boiler. 1. Water level indicator: To indicate water level inside the boiler. 2. Pressure gauge: To measure the pressure of steam inside the boiler 3. Fusible plug: To put off the fire in the furnace of the boiler when the water level in the boiler falls below an unsafe level . 4. Safety valve: To prevent the steam pressure in the boiler from exceeding a predetermined maximum pressure for which the boiler is designed.	1 1.5 mark each for any 2 boiler mounting and its uses	4
3-c	**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 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	2 2	4

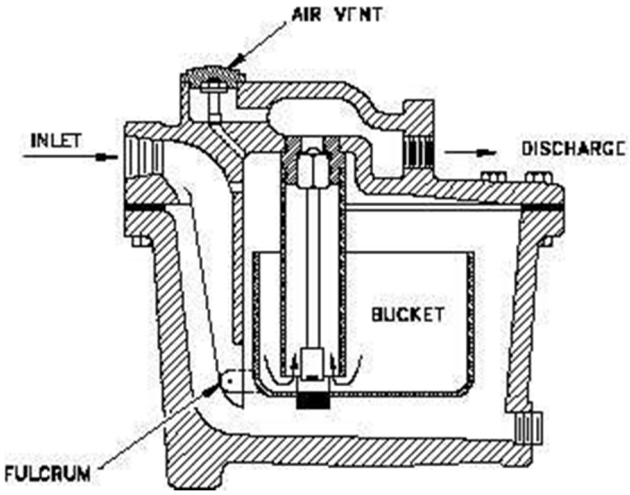
	which do not break easily.		
3-d	**Fluidized bed boiler:** In fluidized bed boiler, coal upto 12mm size can be burned while they are suspended in an agitated state within the combustor, using air blown in from the bottom. Fuels like bagasse rice husk, paper sludge, etc can be used. The major problem 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 2	4

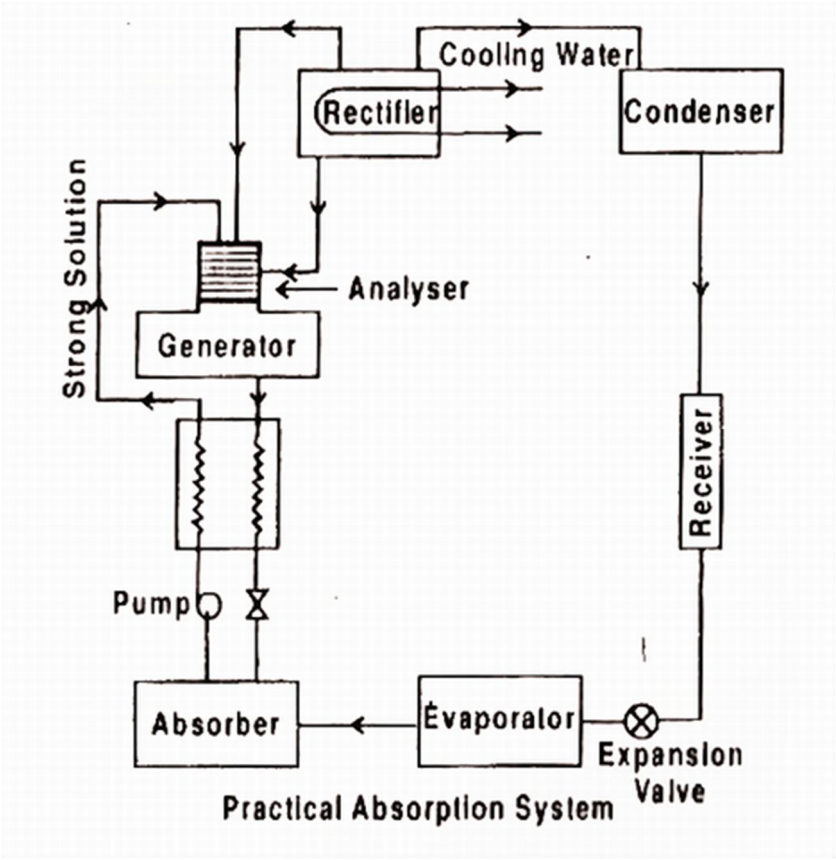
3-e	**IBR and Non IBR boiler:** An IBR boiler is a vessel containing 22.5 liters of water which is used to generate steam. Generally any boiler above 1000kg/hr capacity is an IBR boiler. Non IBR boilers are coil type water tube boilers available in capacity of 200-800 kg/hr.	2 2	4
3-f	**Reverse osmosis:** When two solutions of unequal concentrations are separated by a semi permeable membrane and if a hydrostatic pressure in excess of osmotic pressure is applied on the concentrated side, the solvent is forced to move from the concentrated side to dilute side across the membrane. This is known as reverse osmosis. **Description :**  In this process, pressure of the order of 400 * 10^4N/ m^2 is applied to the impure water / seawater to be treated to force it pure water out through the semi permeable membrane, leaving behind the dissolved salts.	2 1 1	4

4-a	**Impurities in water:** Impurities in 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	1 mark each	4
4-b	**Sling psychrometer**  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	2 2	4

	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.		
4-c	**Properties of Dowtherm A** 1. This fluid is an organic compound of high heat stability. 2. At room temperature, it is clear, almost odourless liquid, which darkens rapidly in use without change in physical characteristics. 3. It does not react chemically with metals. 4. It is non toxic. 5. At its freezing point of 54^0F, it contracts slightly. **Uses of Dowtherm A** Used in the temperature range of 450^0F-750^0F 1. In PET and plastic production . 2. Solar plants 3. Manufacture of synthetic rubber, artificial fibers, and pigments.	2 2	4
4-d	**Advantages of multistage compression** 1.Interstage cooling can be provided thereby reducing the discharge gas temperature. 2. Work done in compressing the air is reduced, thereby saving the power. 3.The suction and delivery valve remains in cleaner condition as the temperature and vaporization of lubricating oil is less. 4. Prevents mechanical damage as air temperature is controlled.	1 mark each	4
4-e	**Dry bulb temperature:** It is the temperature measured with the help of an ordinary thermometer. **Relative humidity:** It is the ratio of actual partial pressure of vapour in the gas to the saturation	2 2	4

	partial pressure		
4-f	i) wet bulb temperature of heated air = 15^0c (From psychrometric chart) ii) RH of heated air = 41% (From psychrometric chart) iii) From psychrometric chart Enthalpy of air at 15^0c=35KJ / Kg Enthalpy of air at 25^0c=45KJ / Kg Volume (at DBT=15^0c)=0.827m^3/Kg Mass of air circulated / min = 200/0.827=241.84kg Heat added to air per minute = 241.84(45-35)=2418.4KJ	1 1 2	4
5-a	**Caustic embrittlement**: Sometimes cracks appear inside the boiler particularly at those places which are under stress such as riveted joints, with the result that the metal plates become brittle. This type of effect is known as caustic embrittlement as it is caused by the water containing carbonate and bicarbonate of alkali metal, sodium hydroxide, etc. The concentration of the causing alkalinity in water is particularly high near the rivets. Thus cracks mostly appear at such places. **Prevention of caustic embrittlement**: 1.Caustic embrittlement can be prevented by adding inhibitors (e.g.sodium sulphate, sodium phosphate etc.) 2.using tannin, lignin etc.	2 2	4

5-b	**Bucket steam trap:**  	4	4
5-c	**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 etc.	1 mark each	4
5-d	**Psychrometric chart:** 1. The DBT of unit mass of dry air for different humidity contents or humidity ratios are indicated by vertical lines drawn parallel to the ordinate. 2. The mass of water vapors in Kg. per Kg. of dry air is drawn parallel to the abscissa for different values of DBT. It is the major vertical scale of the chart. 3. Pressure of water vapor in mm of Hg. is shown in the scale at left and is the absolute pressure of steam. 4. Dew point temperatures are temp. corresponding to B.P of water at low Pressure of water vapor and are shown in the scale of the upper curved line.	4	4

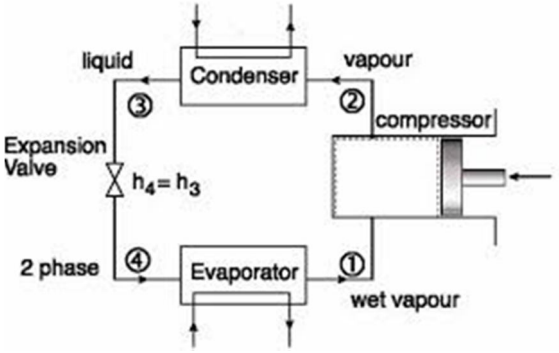
	the dew pt. for different low pressure are read on diagonal co-ordinate. 5. Constant R.H. lines in percent are indicated by making off vertical distance between the saturation line or the upper curved line and the base of chart. Enthalpy in KJ/Kg of dry air is shown by a diagonal system of co-ordinates.		
5-e	**Vapour absorption refrigeration system**  Practical Absorption System **Description of above cycle:** As shows in the schematic diagram of a vapor absorption system. Ammonia vapor is produced in the generator at high pressure from the strong solution of NH3 by an external heating source. The water vapor carried with ammonia is removed in the rectifier and only the dehydrated ammonia gas enters into the condenser. High pressure NH3 vapor is condensed in the condenser. The	1 3	4

	cooled NH3 solution is passed through a throttle valve and the pressure and temperature of the refrigerant are reduced below the Refrigeration Cycles temperature to be maintained in the evaporator. The low temperature refrigerant enters the evaporator and absorbs the required heat from the evaporator and leaves the evaporator as saturated vapor. Slightly superheated, low pressure NH3 vapor is absorbed by the weak solution of NH3 which is sprayed in the absorber as shown in Fig. Weak NH3 solution (aqua–ammonia) entering the absorber becomes strong solution after absorbing NH3 vapor and then it is pumped to the generator through the heat exchanger. The pump increases the pressure of the strong solution to generator pressure. The strong NH3 solution coming from the absorber absorbs heat form high temperature weak NH3 solution in the heat exchanger. The solution in the generator becomes weak as NH3 vapor comes out of it. The weak high temperature ammonia solution from the generator is passed to the heat exchanger through the throttle valve. The pressure of the liquid is reduced to the absorber pressure by the throttle valve.		

5-f			1 mark each for any four	4

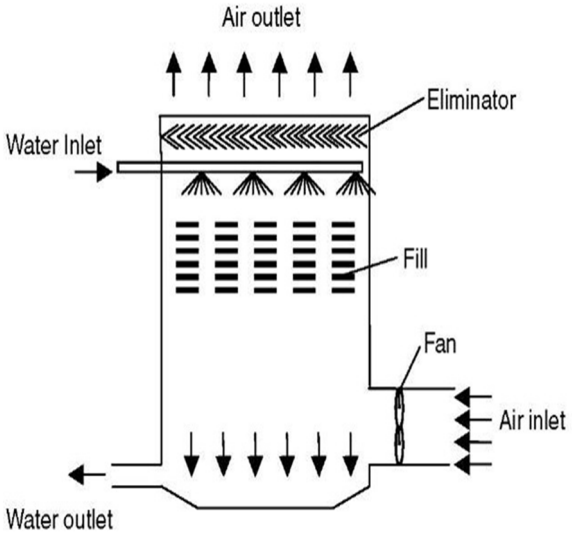
S. No.	Particulars	Fire-Tube Boiler	Water-Tube Boiler
(i)	Position of water and hot gases	Hot gases inside the tubes and water outside the tubes.	Water inside the tubes and hot gases outside the tubes.
(ii)	Mode of firing	Generally internally fired	Externally fired
(iii)	Operating pressure	Operating pressure limited to 16 bar.	Can work under as high pressure as 100 bar.
(iv)	Rate of steam production	Lower	Higher
(v)	Suitability	Not suitable for large power plants.	Suitable for large power plants.
(vi)	Risk on bursting	Involves lesser risk on explosion due to lower pressure	Involves more risk on bursting due to high pressure

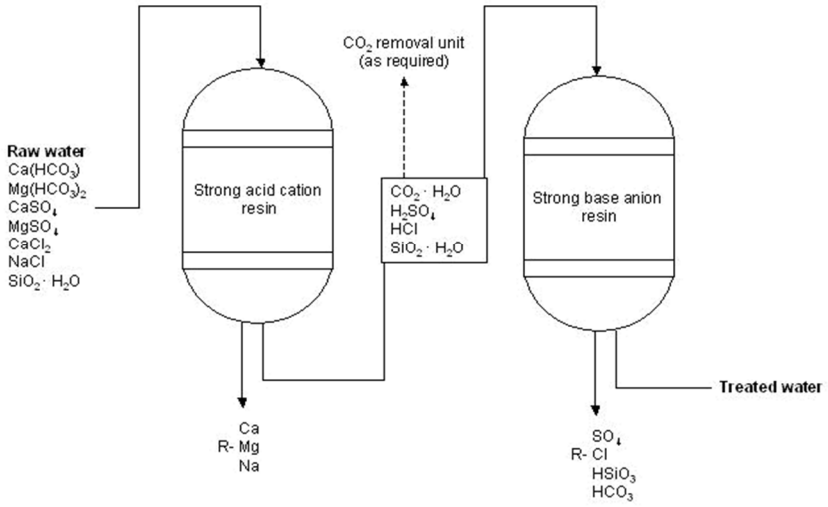
6-a	**Vapour compression system:**		2	8



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 . Figure shown single-stage vapor-compression system. All such systems have four components: a compressor, a condenser, a thermal expansion valve and an evaporator. Circulating refrigerant enters the compressor and compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed vapor is then condensed with either cooling water or cooling air. That hot vapor is routed through a condenser

6

	where it is cooled and 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 is next routed through an expansion valve where it undergoes an abrupt reduction in pressure.		
6-b	**Types of cooling towers:** Natural draft atmospheric spray tower Natural draft deck-type tower Forced draft cooling tower induced draft cooling tower **Forced draft cooling tower**:  **Description** :the construction of the forced draft tower is shown in fig. the water from the condenser is sprayed at the top of the tower and air is forced by the blower from the bottom of the tower at shown in fig. the air velocity of 120	2 3 3	8

	m/min is recommended with a flow of 100 to 190 cu.m. per minute per tone of refrigeration capacity.		
6-c	**Types of water softening method:** Pre-boiling of water Lime–soda process Zeolite process Ion-exchanger process **Ion-exchanger process:**  **Description:** In this process, hard water is passed through cation exchanger which removes all the cations like Ca^{++} etc and equivalent amount of H^+ ions are released from this column to water. After cation exchangrer column, hard water is passed through anion exchanger which removes all the anions like Cl^-, SO_2^{--} present in water and an equivalent amount of OH^- ions are released from this column to water. Cation exchanger resin: These are capable of exchanging cations in water by hydrogen ions. The resins	2 3 3	8

	such as sulphonated coals, tannin formaldehade reprented as RH2 are the example. Their exchange reaction with cations can be reprented as $RH_2 + Ca^{++} \rightarrow RCa + 2H^+$ These cation exchanges when exhausted can be regenerated by acid solution $RCa + 2HCl \rightarrow RH_2 + CaCl_2$ Anion exchanger resins: These are capable of exchanging anion in water by hydraulic ion. The functional group in anion exchangers are $-N(CH_3)_2^+$, $OHNH_2$. The $N(CH_3)_2^+$ and –OH group are stable and react fast. These exchangers are reprented by $R(OH)_2$ $R'(OH)_2 + SO_4 \rightarrow R'SO_4 + 2OH$ Anion when exhausted regenerated by alkali solution. $R'SO_4 + 2NaOH \rightarrow R'(OH)_2 + Na_2SO_4$		