WINTER-18 EXAMINATION

Model Answer

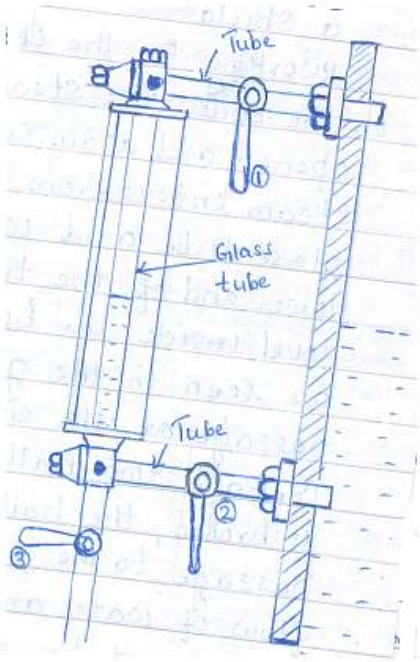
Subject title: Plant Utilities Subject code 22311

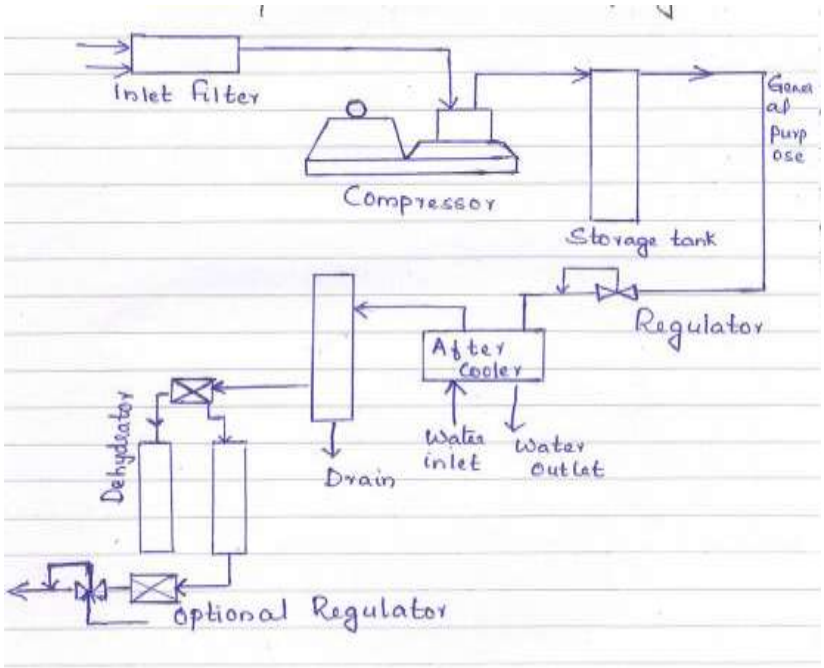
Important Instructions to examiners:

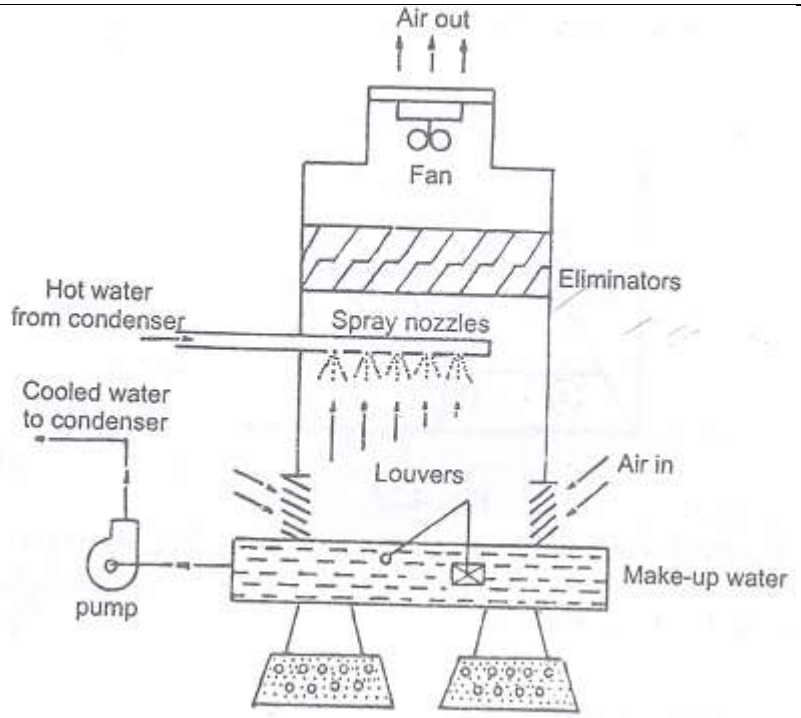
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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 A		**Attempt any five**	**10**
1	a	**Salts causes temporary hardness:** Bicarbonates of calcium and magnesium **Salts causes permanent hardness:** Chlorides and sulphates of calcium, magnesium or other heavy metals.	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	**Uses of compressed air:** 1. Used in automatic controllers to control the process 2. Used in oxidation of acetaldehyde to acetic acid. 3. Used for instrumentation for automatic recording and controlling 4. Used in ventilation 5. Used in oxidation of nitrogen oxide to nitrogen dioxide in nitric acid plant.	1/2 mark each for any 4
1	d	**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	2

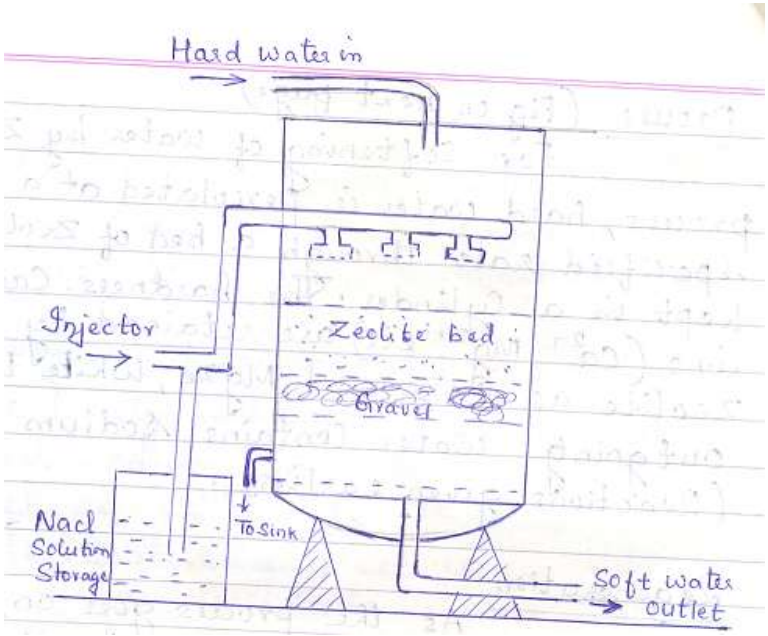
1	e	**R-22** is monochlorodifluoromethane(CHClF2) or Freon-22 **Properties of R-22: (any 4)** 1. Stable 2. Non toxic 3. Non corrosive 4. Non irritating 5. Non inflammable 6. Boiling point 0f -40.80C at atmospheric pressure 7. Good solubility in oil up to -100C 0C	½ mark each
1	f	**i)Dry bulb temperature:** Temperature recorded by ordinary thermometer is called dry bulb temperature. **(ii)Wet bulb temperature:** It is the temperature indicated by thermometer whose bulb is covered with cotton or muslin wire wetted with moisture	1 1
1	g	**(i) Absolute humidity:** It is the weight of water vapour per unit weight of dry air or gas. **(ii)Relative humidity:** Relative humidity is the ratio of actual partial pressure of vapour in the gas to the saturation partial pressure, at a given temperature and volume of gas.	1 1
2		**Attempt any three**	12
2	a	**Reactions take place with hard water in hot lime soda process(any 4)** $2HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O$ $H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$ $Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$	1 mark each

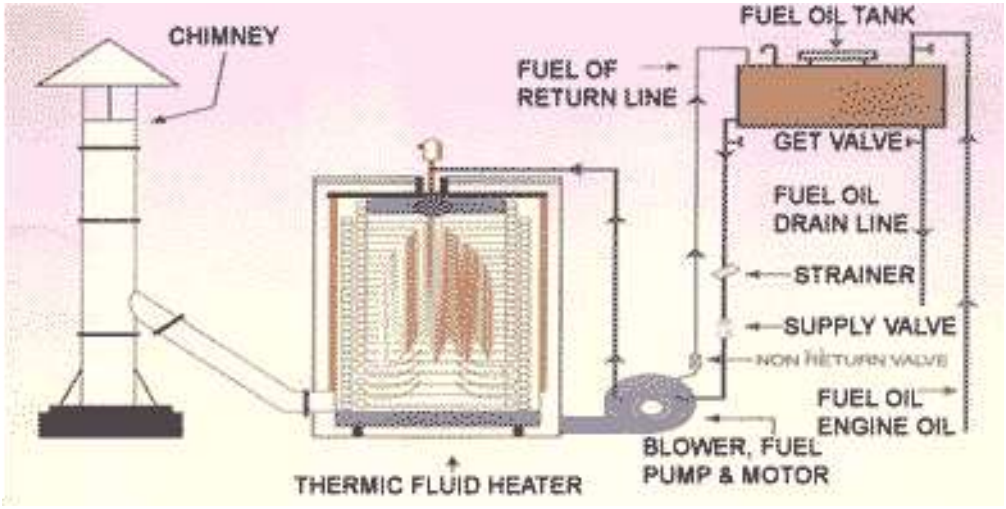
		$Mg(HCO_3)_2 + 2\ Ca(OH)_2 \rightarrow 2CaCO_3 + Mg(OH)_2 + 2H_2O$ $MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaCl_2$ $MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaSO_4$ $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$ $CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 + Na_2SO_4$	
2	b	**Water level indicator:**  **Working:** 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
2	c	**Compressed air:**	

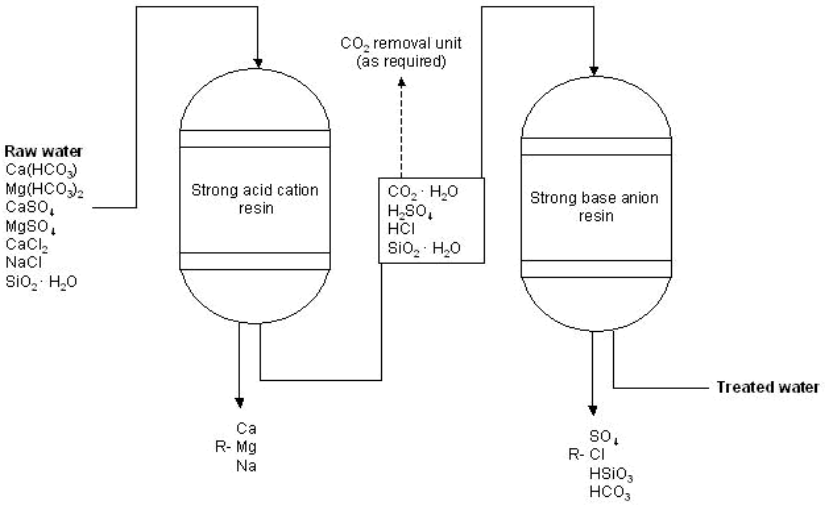
		Air is passed through a filter to remove suspended impurities. The filtered air is supplied to the compressor. Discharge from the compressor will be at a pressure of 100 to 150 psi, which is stored in a storage tank. When required it is passed through a regulator and then through an after cooler to remove 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 constant reduced pressure in the supply line.	2
			2
2	d	**Induced draft cooling tower**:	2

		 **Working:** 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. The air velocity of 120 m/min is recommended with a flow of 100 to 190 cu.m per min per ton of refrigeration capacity. The amount of water usually lost with induced draft cooling tower ranges from 1 to 2% by evaporation and ½ to 2% by draft losses. The water for compensating these losses is supplied from external source. The water must be chemically treated to avoid the scale formation of the condenser due to increase in concentration of salt in the cooling tower.	2
3		**Attempt any three**	12
3	a	**Foaming:** It is the phenomenon of formation of foam or bubbles on surface of water which do not break easily.	1/2

		Priming: It is a phenomenon caused by very rapid boiling of water inside the boiler with the result that the water particles get mixed up with steam. It is due to the presence of large quantities of dissolved organic oily matter, suspended material etc. **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. **Caustic embrittlement:** It is a type of boiler corrosion caused by using highly alkaline water in the boiler. In high pressure boiler, sodium carbonate decomposes to give NaOH and CO_2 and this makes boiler water caustic. NaOH containing water flows in to the minute hair cracks always present in the inner side of the boiler by capillary action. Here water evaporates and the dissolved caustic soda concentration increases progressively. This caustic soda attacks the surrounding are, thereby dissolving iron of the boiler as sodium ferroate. This causes embrittlement of boiler parts; particularly stressed parts like bends, joints, rivets etc causing even failure of the boiler. **Prevention:** 1. By using sodium phosphate instead of sodium carbonate for softening water. 2. By adding tannin or or lignin to the boiler water, since these block the minute cracks therby preventing infiltration of caustic soda solution. 3. By adjusting the alkalinity of water to optimum level (pH- 7 to 9)	1/2 1 1 ½ mark each for any 2

3	b	**Zeolite process for water softening:**  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+} 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. 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 $NaHCO_3$	2 2

3	c	**Thermic fluid heater:** **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.  	2 2
3	d	**Duties of boiler inspector**(any 4) 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		**Attempt any three**	**12**
4	a	**Ion-exchanger process:**	2 marks for



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 such as sulphonated coals, tannin formaldehade reprented as RH2 are the example. Their exchange reaction with cations can be reprented as

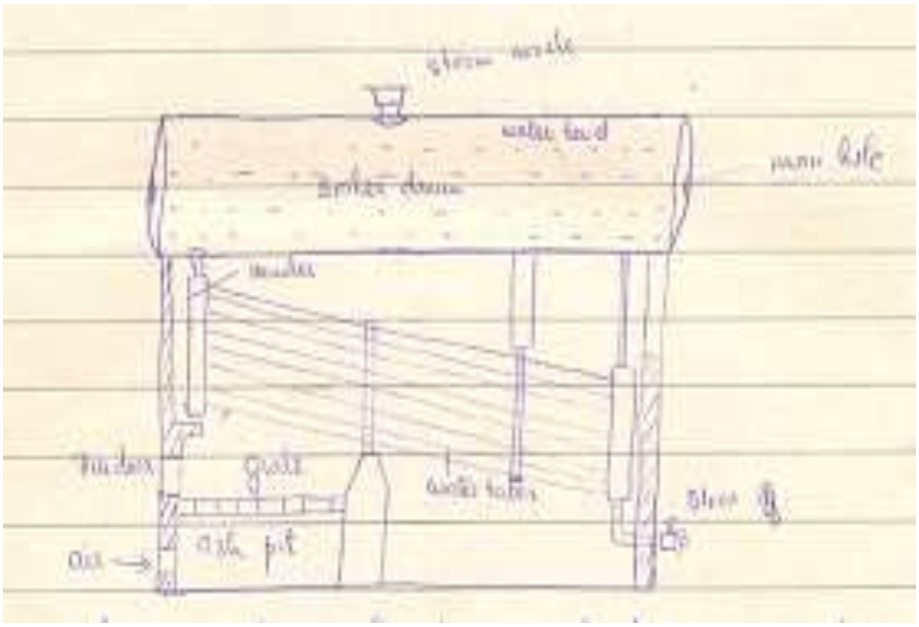
$RH_2 + Ca^{++} \rightarrow RCa + 2\,H^+$

These cation exchanges when exhausted can be regenerated by acid solution

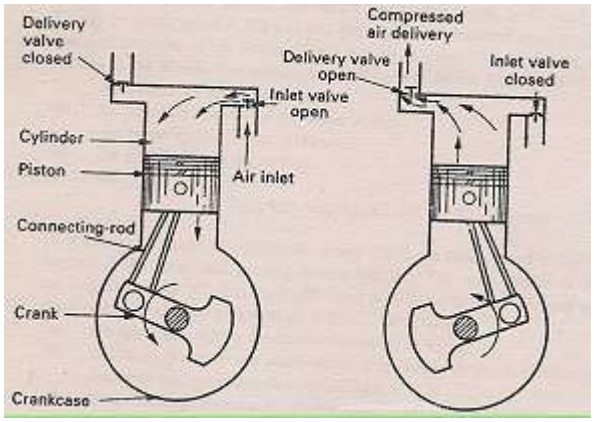
$RCa + 2\,HCl \rightarrow RH_2 + CaCl_2$

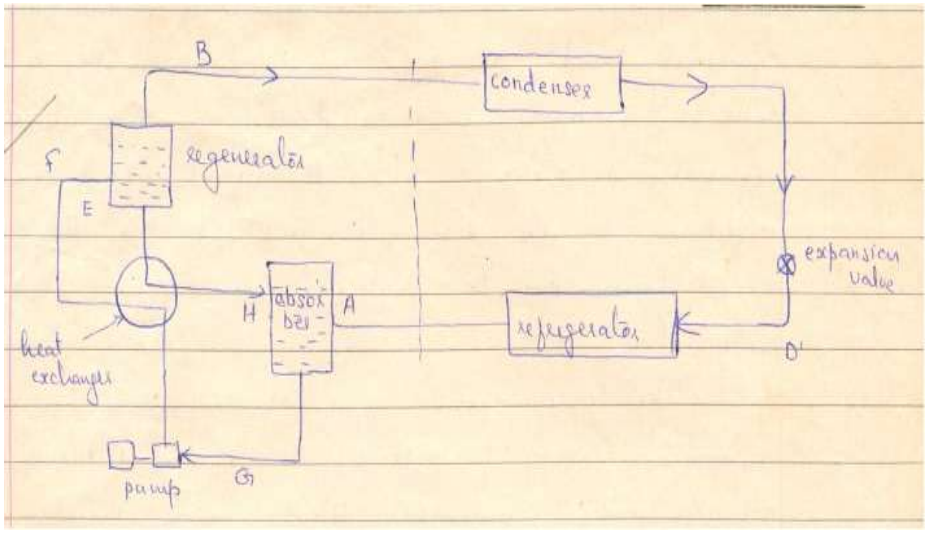
Anion exchanger resins:

diagram and 2 marks for description

		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 $R(OH)_2$ $R'(OH)_2 + SO_4 \rightarrow R'SO_4 + 2\,OH$ Anion when exhausted regenerated by alkali solution. $R'SO_4 + 2\,NaOH \rightarrow R'(OH)_2 + Na_2SO_4$	
4	b	**Babcock and Wilcox boiler**  **Advantages:** 1. Steam of high pressure is generated **2.** High capacity 3. more efficient circulation found in water-tube than in fire-tube boilers 4. their ability to raise steam rapidly in starting and to meet the sudden	3 1/2 mark each for any 2

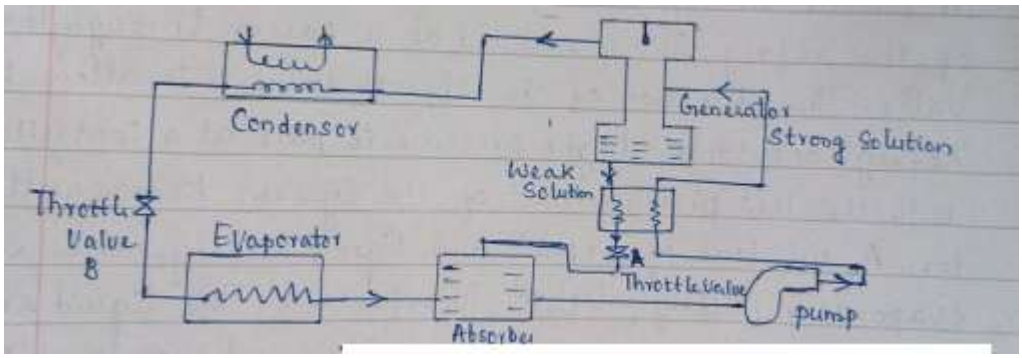
		demands that may be thrown on them. 5.ability to keep heating surfaces clean internally and externally 6. saving in space The space required for the boilers in a plant 7. water-tube boilers are more accessible	
4	c	**Use of steam trap:** They are used to collect and automatically discharge the water resulting from partial condensation of steam without allowing any steam to escape. **Use of Economizer:** Economizer is used to recover some of the heat from the heat carried away in the flue gases up the chimney and utilize for heating the feed water to the reboiler. By its use, fuel is economized and steaming rate is increased. **Use of pressure reducing valve:** Discard extra pressure to atmosphere for safe working of boiler. for manual control of steam pressure by throttling a valve. It is common practice to set these valves assuming a constant boiler pressure **Use of Air preheater**: It recovers some portion of the waste heat of the flue gases and preheats the air supplied to the combustion chamber.	1 1 1 1
4	d	**Working of air compressor:** An air compressor is a device that convert power (using an electric motor, diesel or gasoline engine, etc.) into potential energy stored in pressurized air (i.e., compressed air). By one of several methods, an air compressor forces more and more air into a storage tank, increasing the pressure. When tank pressure reaches its engineered upper limit the air compressor shuts off. The compressed air, then, is held in the tank until called into use. The energy	4

		contained in the compressed air can be used for a variety of applications, utilizing the kinetic energy of the air as it is released and the tank depressurizes. When tank pressure reaches its lower limit, the air compressor turns on again and re-pressurizes the tank. An air compressor must be differentiated from pump because it works for any gas/air and pump work on liquid.  	
4	e	**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. **Advantages of multistage compression: (any 2)** 1. Reduction in power required to drive compressor	1 1 1 ½ mark each

		2. Metter mechanical balance and uniform torque 3. Reduced leakage loss swing to reduce pressure difference in either side of piston and valves 4. Less difficulty in lubrication 5. Light cylinders	
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	3 marks for diagram and 3 marks for description

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

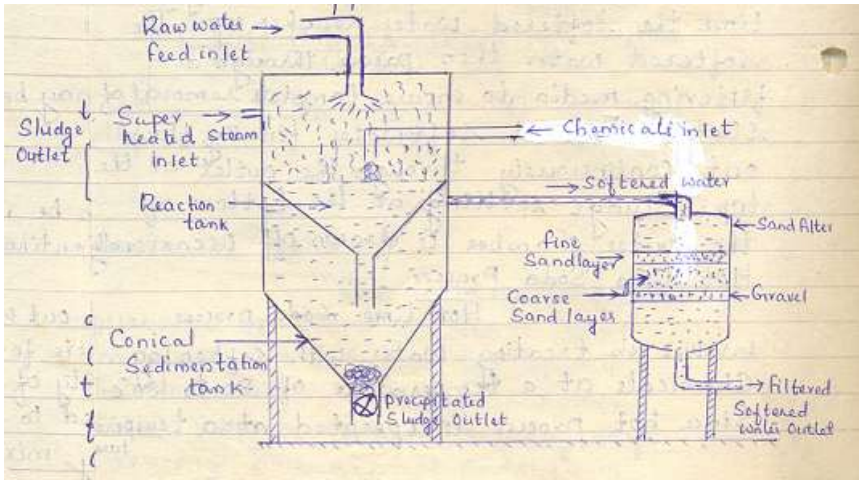
OR



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 driven off.	
5	b	**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. **Selection criteria for refrigerant** (any 4) 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	2 1 mark each

		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.	
5	c	DBT = 33^0C WBT = 23^0C (i)From psychrometric chart, corresponding to DBT = 33^0C & WBT = 23^0C, read from the relative humidity curve where these two points meet. Relative humidity = **46%** (ii)From psychrometric chart, find the intersecting point of DBT = 33^0C & WBT = 23^0C. From there draw a horizontal line to saturation temperature line to get the dew point temperature. Dew point temperature **= 49^0C**	3 3
6		**Attempt any TWO of the following**	**12**
6	a	**Coefficient of Performance**.(COP): It is the ratio of heat removed from the system (Q) to the work supplied to	2

		achieve the heat removal (W). COP = Q / W T1 = 40+ 273 = 313 T2 = -15 + 273 = 258 C.O.P. = T2/(T1 - T2) = 258 / (313- 258) = **4.69**	 2 1 1
6	b	**Hot lime soda process**  **Construction:** It consists of a 1. Reaction tank in which raw water, chemicals (slaked lime and soda ash) and steam are thoroughly mixed at 80-100^{0}c. 2. Conical sedimentation vessel in which the sludge settles down 3. Sand filter which ensures complete removal of sludge from the softened water. **Working:**	2 2

		Hard water, chemicals are added to the reaction tank . Steam is added to increase the temperature of water. The precipitate settles at the bottom and the softened water is passed through a sand filter to get filtered. The reactions are $2HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O$ $Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$ $MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaCl_2$ $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$	2
6	c	**Indian boiler act with respect to** **(i)Boiler registration**: Boilers have to be registered before they can be used. The owner of the boiler shall give an application for the same. The inspector shall examine the boiler and find the maximum pressure at which the boiler may be operated. He will submit his report to the chief inspector and in turn the employer may get authorized for 1 year to use the boiler. **(ii)Certificate of renewal:** After generally 12 months. If boiler is transferred from one state to another. If some accidents is occurs. If some alteration is done in boiler parts , etc. **iii) Transfer of boiler:** When boiler is transferred from one state to another , permission must be taken again from the chief inspector of new state for its installation and operation. **(iv)Penalty:** A penalty of Rs 500 and Rs 100 per day additional after the first day of the	1 1 1

		offence shall be imposed on an occupier of the boiler who (a) Operates a boiler without getting it registered. (b) Refuses to surrender the certificate of operating the boiler. (c) Does not report the transfer of boiler from one state to another and uses it without getting registered. (d) Does not report accident of boiler. (e) Repairs or replace boiler parts without prior permission of the inspector.	2
		(v)Boiler repair and maintenance. Before carrying out boiler repair, permission is obtained from chief inspector. Major boiler repairs and replacements connected with furnace etc are undertaken in the presence of inspector.	1