WINTER-14 EXAMINATION

Model Answer

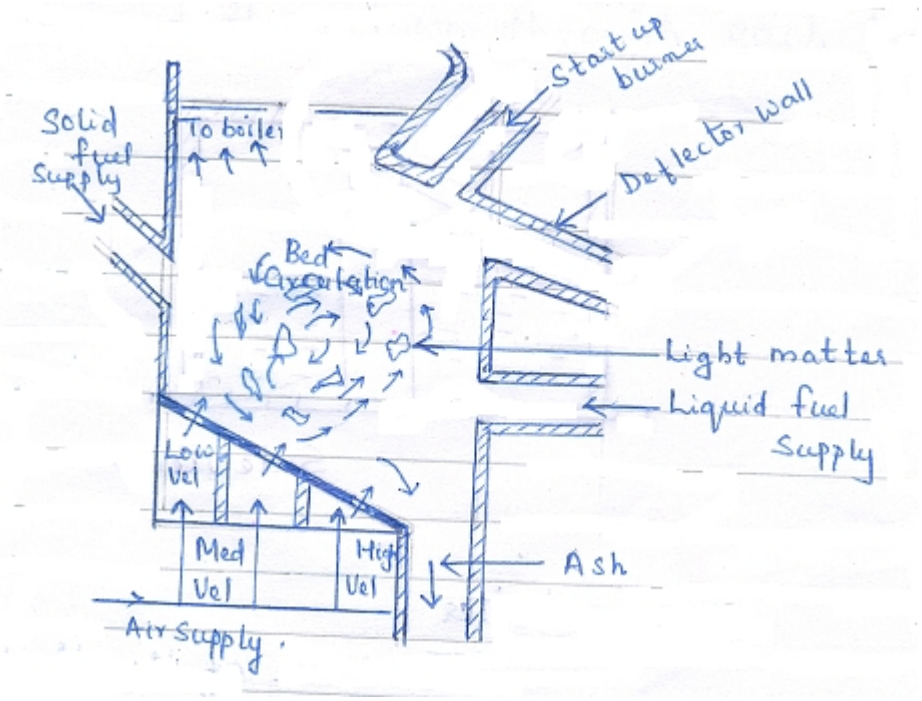
Subject code :(17425)

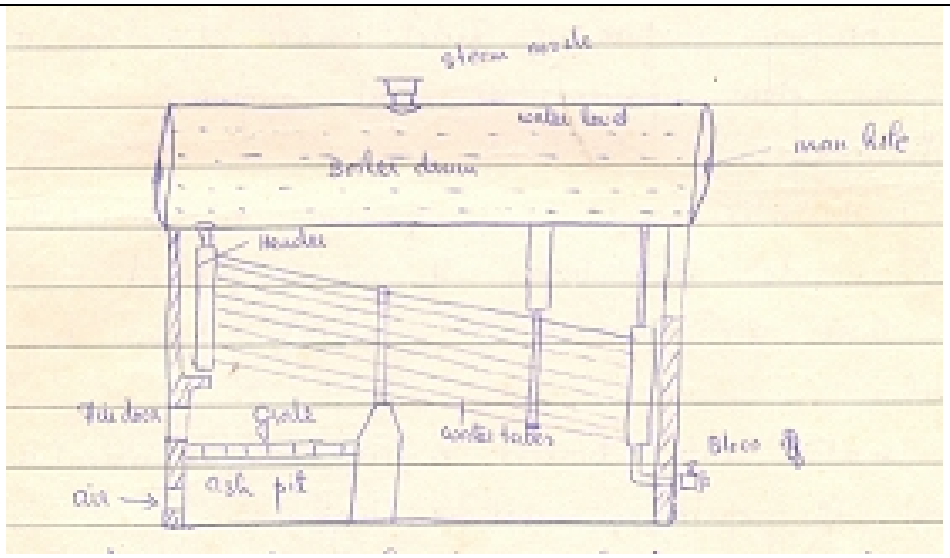
Important Instructions to examiners:

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-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	2
1A-b	**Important refrigerants used in industry:** 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-c	**Relative humidity:** It is the ratio of actual partial pressure of vapour in the gas to the saturation partial pressure **Dew point temperature:** It is the temperature of air at which water vapour in it starts condensing.	1 1	2
1A-d	**Wet bulb temperature:** It is the temperature indicated by thermometer whose bulb is covered with cotton or muslin wire wetted with moisture. **Dry bulb temperature:** Temperature recorded by ordinary thermometer is called dry bulb temperature.	1 1	2

1A-e	**R-22** is monochlorodifluoromethane(CHClF2) or Freon-22 **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 -100C 0C	1/2 mark each for any four	2
1A-f	**Scale formation on the metal surface of boiler:** In boiler, water evaporates continuously and concentration of dissolved salts increases progressively. When their concentration reaches the saturation point, they are thrown out of water in the form of precipitates. Then they stick as hard deposits on the metal surface of the boiler which are known as scales.	2	2
1B-a	**The reactions are :** $2HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O$ $H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$ $Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3 + 2H_2O$ $Mg(HCO_3)_2 + 2\ Ca(OH)_2 \rightarrow 2CaCO_3 + Mg(OH)_2 + 2H_2O$ $MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaCl_2$ $MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaSO_4$ $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$ $CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 + Na_2SO_4$	1 mark each for any four	4
1B-b	**Fluidized bed boiler:** In fluidized bed boiler, coal upto 12mm size can be burned while they are	2	4

	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	
1B-c	**Babcock and Wilcox boiler**	4	4



2-a

Water tube boiler	Fire tube boiler
Content of tube is water	Content of tube is hot gas
Hot gas surrounds the tube	Water surrounds the tube
Eg babcock and Wilcox boiler	Eg. Cochran boiler, locomotive boiler

2 mark each for any two — 4

2-b

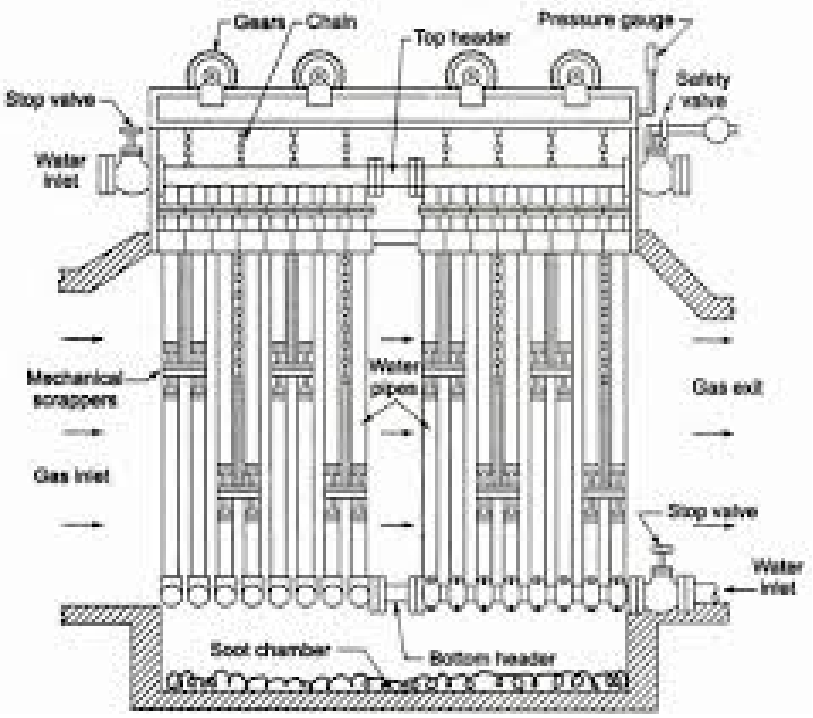
Use of resins in Ion exchange method: — 4 — 4

The resins containing acidic functional group are capable of exchanging their H^+ ions with the cations coming in their contact and the resins containing basic functional group $–NH_2=NH_2$ are capable of exchanging their anion with other anion coming in their contact.

Cation resins are capable of exchanging cation in water by hydrogen ions. These cation exchangers when exhausted can be regenerated by passing through their bed an excess of strong acid solution.

Anion resins are capable of exchanging anion in water by hydroxyl ion. Anion exchangers when exhausted can be regenerated by passing through their bed of

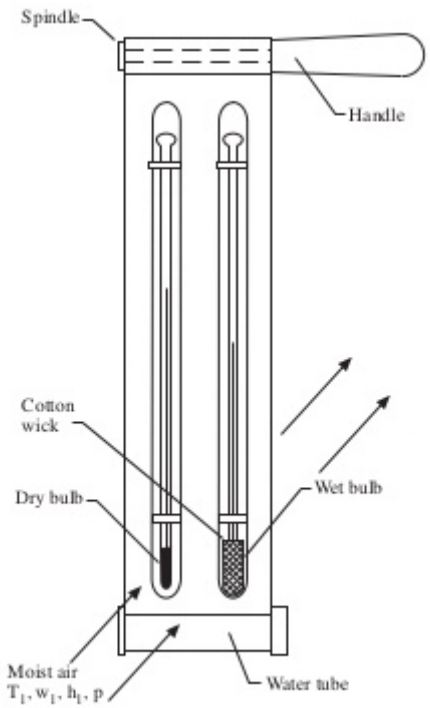
	strong alkali solution.		
2-c	**Classification of boiler:** **1.** Use a. stationary b. mobile 2. Tube contents a. fire tube boiler b. water tube boiler 3. Tube shape and position a. Straight b. Inclination 4. furnace position a. Externally fired boiler b. Internally fired boiler 5. Circulation a. natural circulation b. forced circulation 6. Heat source a. Fuel b. hot waster gaes c. electrical energy d. nuclear energy	1 mark each for any 4	4
2-d			4

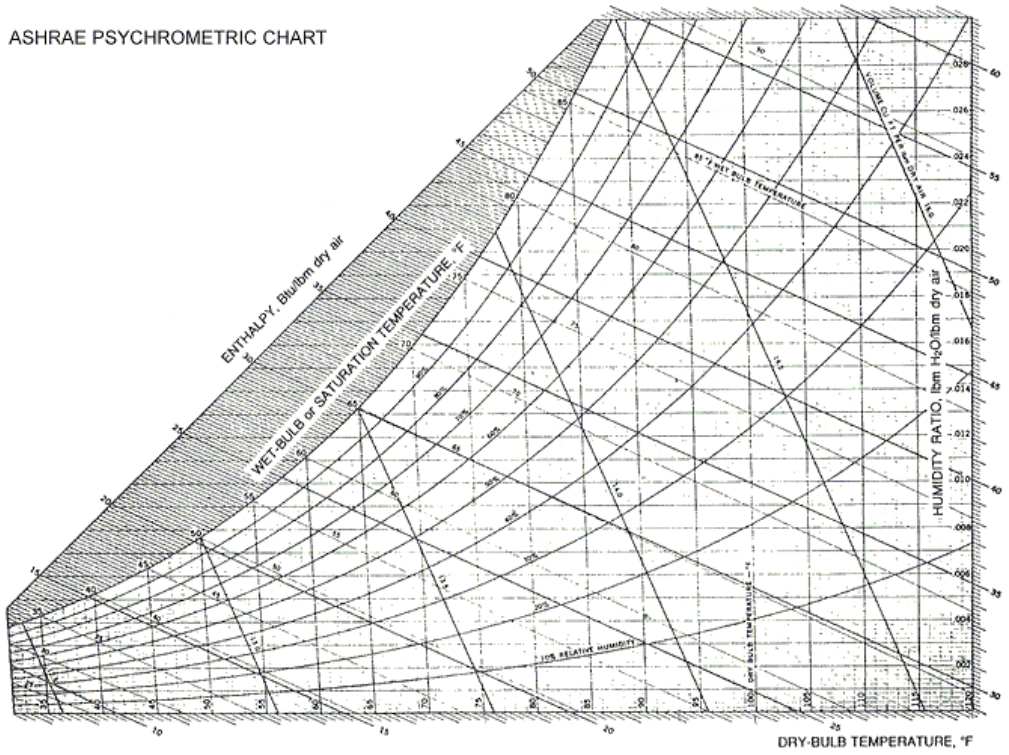
	 **Working** : Function of economizer is to recover some of the heat from the heat carried away in the flue gases up the chimney and utilized for heating the feed water to the boiler. From the water inlet water goes to be bottom boxes and raises up in the vertical pipes into the top boxes. From the top boxes it goes to the pipe from where it goes to be water space of boiler. Flue gas passes perpendicular to the tubes.	4	
2-e	**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.	4	4

	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. 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.		
2-f	**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 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.	2 2	4
3-a	**Reverse Osmosis** is a water purification technology that uses a semipermeable membrane. This membrane technology is not properly a filtration method. In reverse osmosis, an applied pressure is used to overcome osmotic pressure, a colligative property, that is driven by chemical potential, a thermodynamic parameter. **USES:** Drinking water purification Portable reverse osmosis water processors production of bottled mineral water	1 1	4

	Military use: the Reverse Osmosis Water Purification Unit Water and wastewater purification IN FOOD INDUSTRY FOR concentrating food liquids (such as fruit juices) Maple syrup production. **Description:** In the normal osmosis process, the solvent naturally moves from an area of low solute concentration (high water potential), through a membrane, to an area of high solute concentration (low water potential). The movement of a pure solvent is driven to reduce the free energy of the system by equalizing solute concentrations on each side of a membrane, generating osmotic pressure. Applying an external pressure to reverse the natural flow of pure solvent, thus, is reverse osmosis. The process is similar to other membrane technology applications. However, key differences are found between reverse osmosis and filtration. The predominant removal mechanism in membrane filtration is straining, or size exclusion, so the process can theoretically achieve perfect exclusion of particles regardless of operational parameters such as influent pressure and concentration. Moreover, reverse osmosis involves a diffusive mechanism, so that separation efficiency is dependent on solute concentration, pressure, and water flux rate. Reverse osmosis is most commonly known for its use in drinking water purification from seawater, removing the salt and other effluent materials from the water molecules.	2	
3-b	**Qualities of water for industrial use:** The water should be clear, bright and absolutely free from colour. It should be soft. It should not contain any sediments, oil, algae, bacteria, suspended matter, dissolved salts **Different uses of water in industry:**	2	4

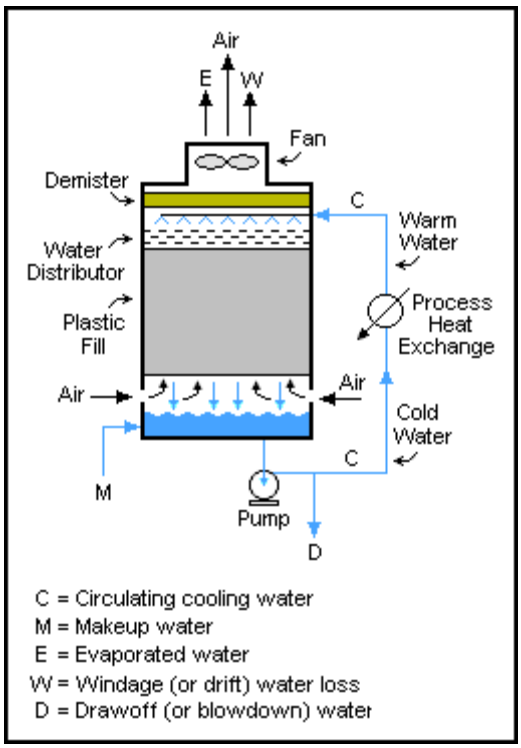
<table>
<tr><td></td><td>1. In chemical reaction
2. Utility(cooling agent)
3. Steam production
4. Cleaning
5. In cooling tower</td><td>2</td><td></td></tr>
<tr><td>3-c</td><td>
<table>
<tr><td></td><td>Thermic fluid</td><td>Temp. Ranges (deg. F)</td><td>uses</td></tr>
<tr><td>1</td><td>Dowtherm A</td><td>53.6 – 495.8</td><td>In heat transport systems, can be used in process equipment which has to be shut down under cold working conditions</td></tr>
<tr><td>2</td><td>Dowtherm E</td><td>-6.7 to 352</td><td>In heat transport systems, can be used in process equipment which has to be shut down under cold working conditions</td></tr>
<tr><td>3</td><td>Therminol FR</td><td>50-600</td><td>Used in fire resistant systems</td></tr>
<tr><td>4</td><td>Oil mobiltherm 600</td><td>20(pour pt.) to >600</td><td>can be used in systems where frequent change of oil and cleaning is not possible</td></tr>
<tr><td>5</td><td>Oil Mobiltherm light</td><td>-20(pour pt.) to >400</td><td>can be used in systems where frequent change of oil and cleaning is not possible</td></tr>
<tr><td>6</td><td>Hydrotherm 750-200</td><td>5 (pour pt.) to ---</td><td>Used in cases where mild steel and copper are used</td></tr>
</table>
</td><td>1 mark each for any four</td><td>4</td></tr>
</table>

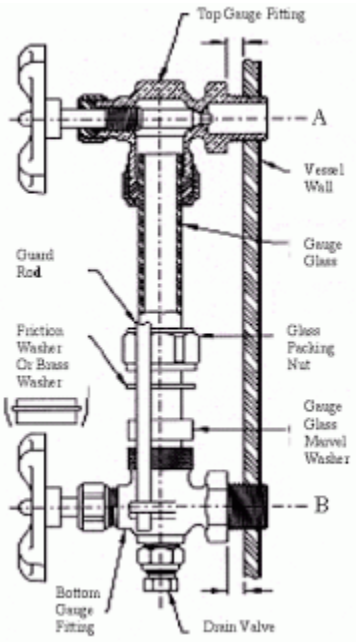
3-d	**Inspection of boiler:** Boiler is inspected before the certificate for its operation is given to its employer. Before inspecting the boiler, It is clean All fittings , such as burners , stokers, etc are removes Valves, cocks etc are open & inspector examine all the parts of boiler, carries the 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.	4	4
3-e	**Sling psychrometer:**  	4	4
3-f	**Caustic embrittlement:**	2	4

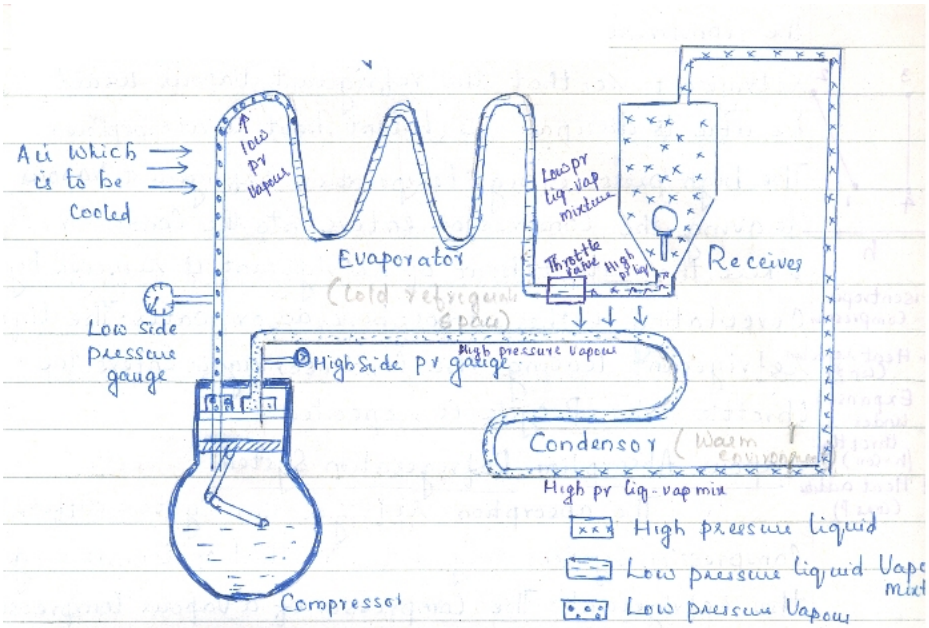
	Sometimes cracks appear inside the boiler particularly at those places which are under stress such as riveted joints , with the result that the metal plates becomes brittle . This type of effect is known as caustic embrittlement as it is caused by the water containing carbonate and bicarbonate of alkali metal, sodium hydroxide etc. **Methods to prevent**: i) By adding inhibitors i.e. sodium sulphate , sodium phosphate etc ii) By use of organic compounds such as tannin , lignin	2	
4-a	Plot the DBT and WBT on psychrometry chart and read out value,  TO determine the dew pt. temp. for given condition, find the intersection of 33 ^{o} C and 23 ^{o} C and move horizontally to the dew pt. temp. the **Dew pt. Temp = 68 ^{o} C** (between 60 and 70) And	2	4

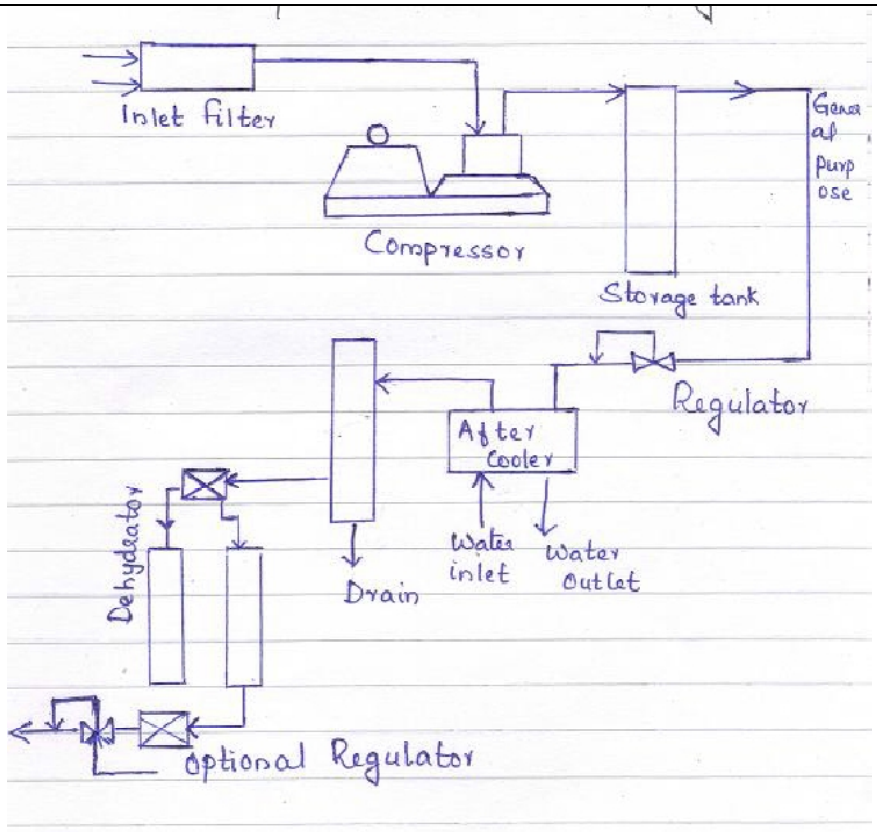
	Relative humidity = 43 %(between 40 and 50)	2	
4-b	**Desirable properties of ideal refrigerant:** 1. It should be chemically inert. 2. It should be non-flammable, non-explosive and non-explosive. 3. It should not react with lubricating oil. 4. It should not have bad effect on the stored material. 5. It should not decompose at temp. normally encountered in the system.	1 mark each for any four	4

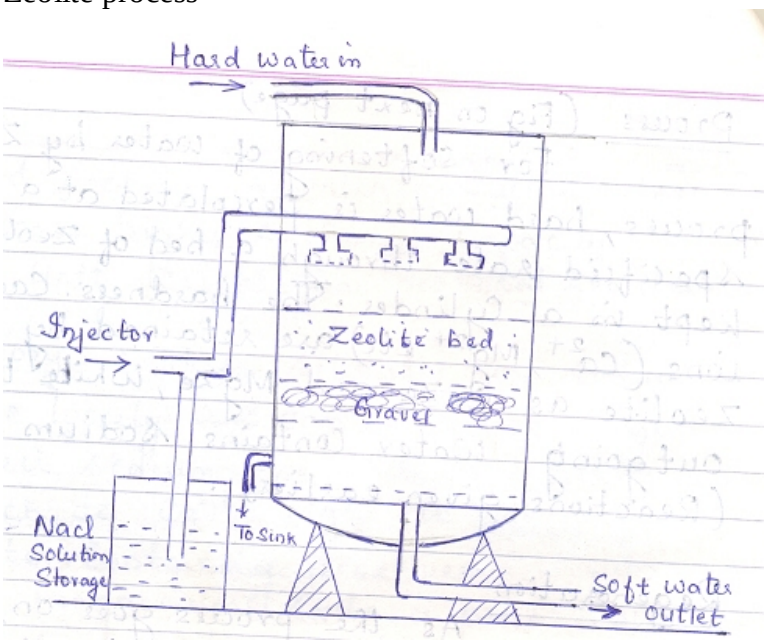
4-c	**Types of cooling tower:**
	Natural draft cooling tower: i)natural draft atmospheric spray tower . ii) natural draft deck-type tower
	Forced draft cooling tower: i)forced draft C.T ii) induced draft C.T.
	diagram:
	• Mechanical draft — Uses power-driven fan motors to force or draw air through the tower.
	  • Induced draft — A mechanical draft tower with a fan at the discharge (at the top) which pulls air up through the tower. The fan *induces* hot moist air out the discharge. This produces low entering and high exiting air velocities, reducing the possibility of *recirculation* in which discharged air flows back into the air intake. This fan/fin arrangement is also known as *draw-through*.
	  • Forced draft — 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
		1
		1
		2 marks for description of any one
			4

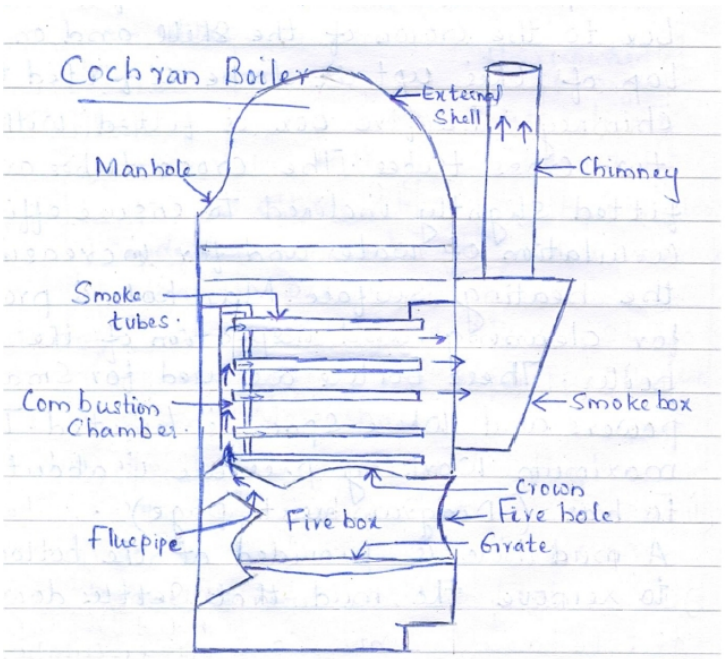
	horsepower than an equivalent induced draft design. The benefit of the forced draft design is its ability to work with high static pressure. Such setups can be installed in more-confined spaces and even in some indoor situations. This fan/fill geometry is also known as *blow-through*.  		
4-d	**Advantage 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	1 mark each for any four	4

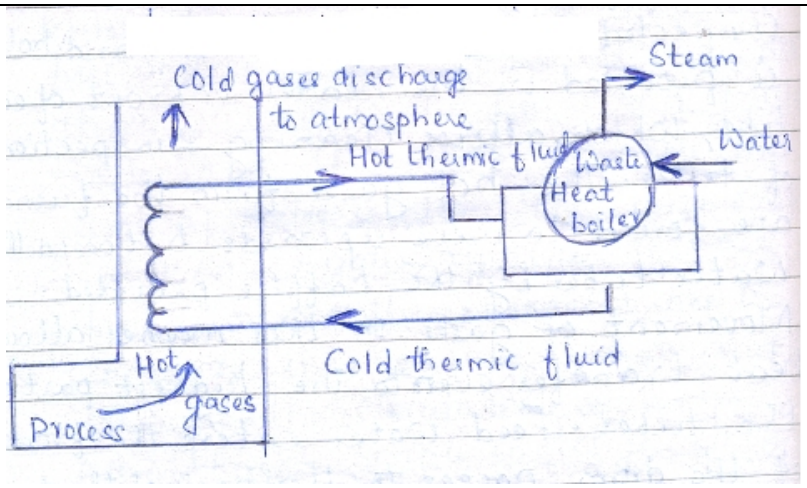
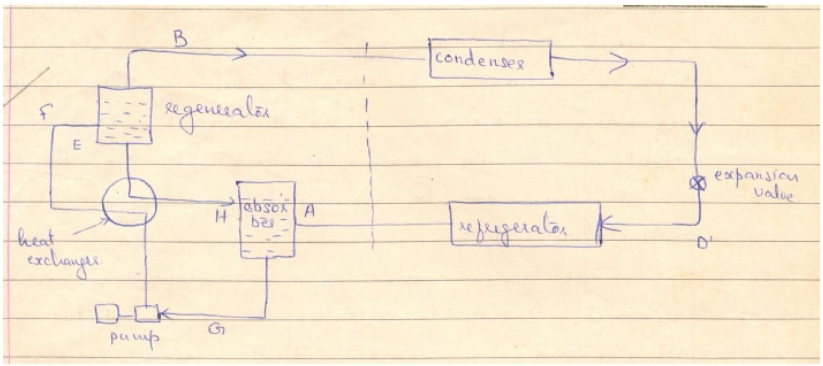
	(7) Low maintenance cost (8) Quiet and easy to operate		
4-e	**Water level indicator:**  It consists of a glass tube, two gun metal tubes and three cocks. The steam cock C1 is provided on the gun metal tube M1 which connects the glass tube with the steam space in the boiler. The water cock C2 is provided on the gun metal tube M2 which connects the glass tube with the water space. The gun metal tubes M1 and M2 are bolted to the boiler shell. The drain cock C3 is used to drain the water from the glass tube at intervals to ascertain whether the gauge is in proper order or not. The glass tube is protected by means of a cover, made of specially toughened glass which will prevent any accident that may happen due to the breaking of glass tube.	2 2	4
4-f	**Boiler repair:** before carrying out boiler repair , permission is obtained from chief inspector.		4

	Major boiler repair and replacement connected with furnace , etc. are undertaken in the presence of the inspector. **Boiler registration**: Boiler 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 max.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.	2 2	
5-a	**Refrigeration:** Refrigeration is maintaining a temperature lower than the surrounding temperature by using proper refrigerant. **Labeled diagram of Vapour compression cycle:** 	1 3	4
5-b	**Process of converting moist air into instrument air:**		4

	 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	
5-c	**Boiler mountings** They are devices mounted on the boiler which are essential for the safe working	2	4

	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.	2 marks for any two mountings with their uses	
5-d	Zeolite process  For softening 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 → CaZe+ 2NaCl(or Na_2SO_4) $MgSO_4$ (or $MgCl_2$) + Na_2Ze → MgZe+ 2NaCl(or Na_2SO_4) $Ca(HCO_3)_2$ (or $Mg(HCO_3)_2$ + Na_2Ze → CaZe (or MgZe) + 2 $NaHCO_3$	2 2	4

5-e	**Labeled diagram of Cochran boiler** 	4	4
5-f	**Industrial Uses of air:** 1. Used in chemical process in oxidation reactions. 2. Used in automatic controllers to control the process. 3. Used in the production of oxygen and nitrogen. 4. Used in refrigeration system. 5.Used for drying purpose 6. Used in furnace, boilers 7. Used in the manufacture of chemicals like sulphuric acid, nitric acid etc. 8. Used for driving tools like pneumatic hammers. 9. Used in cooling tar	1 mark each for any four points	4
6-a	**Waste heat recovery boiler:**		8

	 It is possible to use process waste heat of high temperature exhaust gases from any chemical / physical process for running a boiler because hot gases contain high calorific value. However boiler is very costly and complicated equipment. It will tend to get easily corroded due to dirty and corrosive hot gases. Moreover its heating surface will also get dirty. Therefore instead of directly raising steam from waste heat, an intermediate thermic liquid like dowtherm, mineral oil etc is used. Thermic liquids have boiling point higher than water. They absorb heat from hot gases and then give it again to a boiler for steam raising. The use of thermic fluid saves costly boiler from corrosion and also improves the overall recovery process.	3 5	
6-b	**Vapour absorption cycle:** 	3	8

	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.	5	
6-c	From steam table, corresponding to a pressure of 10 bar, h_f = 762.6 KJ/ Kg h_{fg} = 2013.6 KJ/ Kg S_f = 2.138 KJ/ KgK S_{fg}= 4.445 KJ/ KgK	4	8
	(i) When steam is dry and saturated		
	Enthalpy of steam = $h_f + h_{fg}$ = 2776.2 KJ	1	
	Entropy of steam = $S_f + S_{fg}$ = 6.583 KJ /K	1	
	(ii) When steam is 75% dry		

	Enthalpy of steam = $h_f + x\, h_{fg}$ = 762.6 + 0.75* 2013.6 =	1	
	= 2272.8 KJ		
	Entropy of steam = $S_f + xS_{fg}$ = 2.138 + 0.75*4.445	1	
	= 5.47175 KJ /K		