SUMMER-17 EXAMINATION

Model Answer

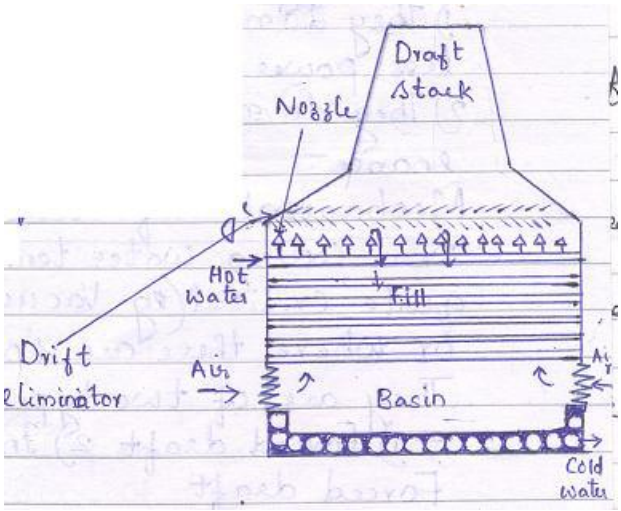
Subject code 17425

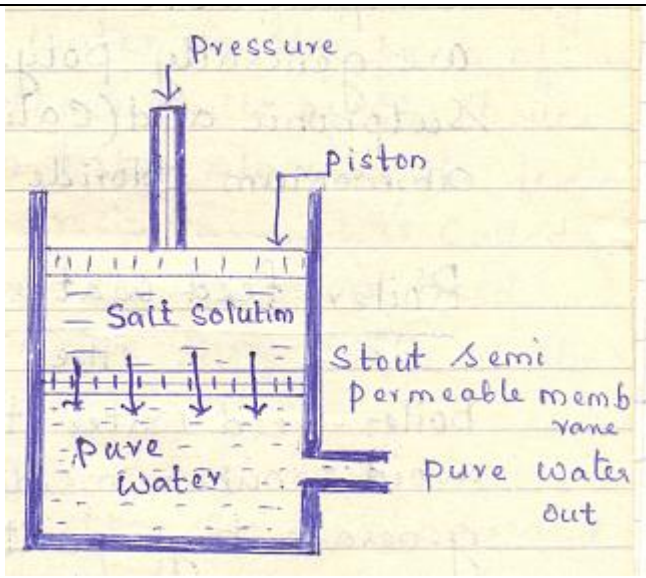
Important Instructions to examiners:

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	Marking scheme
1 A	Attempt any six	12
1A-a	**Hard water**: Contains dissolved salts of calcium and magnesium. It does not produce lather with soap solution. **Soft water:** Does not contain dissolved salts of calcium and magnesium. It produces lather or foam with soap	1 1
1A-b	**Scale and sludge in 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. If the precipitates are loose and slimy it is called as sludge. When they stick as hard deposits on the metal surface of the boiler they are known as scales.	2
1A-c	**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
1A-d	**Steam trap:** They are used to collect and automatically discharge the water resulting from partial condensation of steam without allowing any steam to escape.	2
1A-e	**Elements involved in humidity chart**(any 4) 1. Specific humidity 2. Wet bulb temperature	½ mark each

	3. Dry bulb temperature 4. Relative humidity 5. Specific Volume 6. Saturation temperature 7. Enthalpy	
1A-f	**Interstage cooling are required in multistage compressor:** To cool the compressed air to atmospheric temperature before entering the next stage.	2
1A-g	**Difference between boiler and thermic fluid heater:** **Boiler: Boiler is used to generate steam** **Thermic Fluid Heater :** Thermic fluid heater boiler has been widely used in various applications for indirect heating process. By using petroleum fluids as heat transfer medium, these heaters provide constant temperature. Combustion system consists of fixed grate with mechanical draft arrangements.	2
1 B	**Attempt ant two**	8
1B-a	**(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 **(iii)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. OR	1 1 1

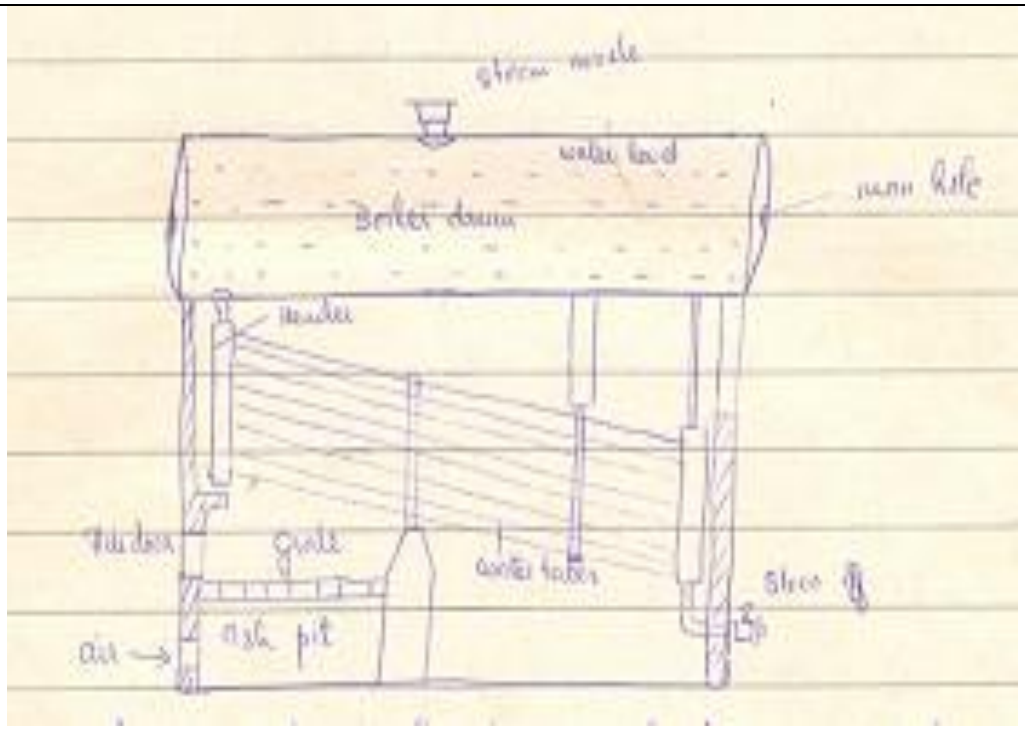
	It is the ratio of mass of water vapour in air of given volume at a given temperature to the mass of water vapour in same volume at same temperature when air is saturated **(iv) Absolute humidity:** It is the weight of water vapour per unit weight of dry air or gas.	1
1B-b	**Natural draft cooling tower** 	4
1B-c	**Reverse Osmosis:**	4



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 , the the first drop of pure water flows in the direction of the arrow from the solution compartment to the pure water compartment when the applied pressure equal the osmotic pressure value of the solution. The applied p must be much greater than the osmotic pressure. Description: It is the process of filtration. In this , we take water with salt in it , an apply pressure to it against a certain type of

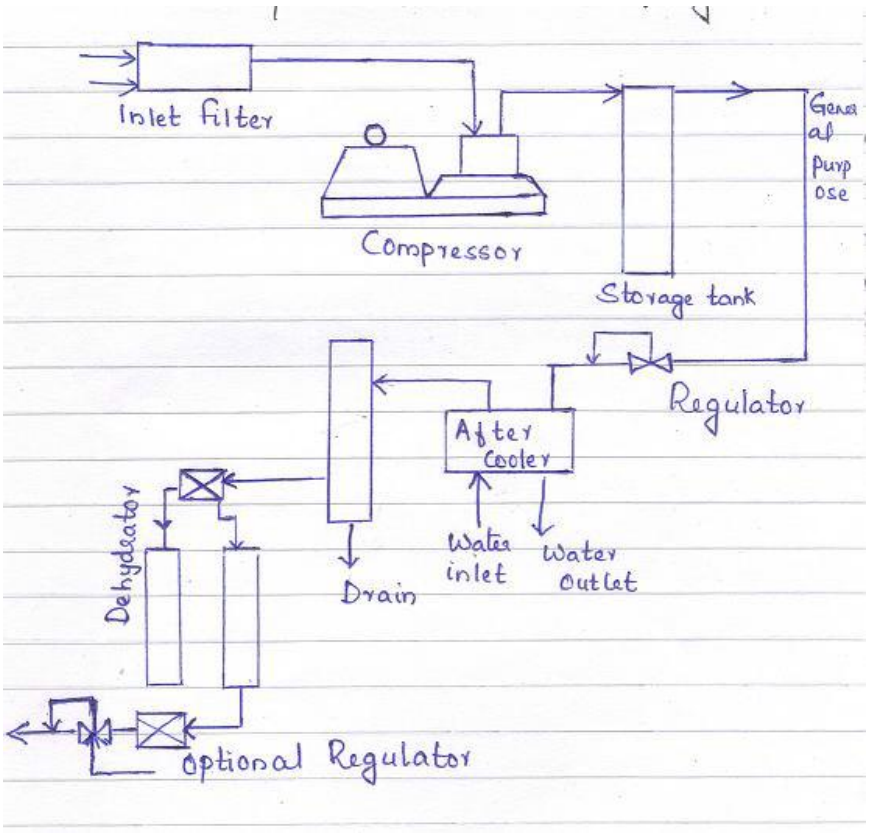
	membrane and presto out comes clean water. Two chamber are separated by an osmotic membrane. Right hand compartment has pure water in it. Left hand compartment has salt solution. If left alone , pure water floe in the direction of the arrows from the pure water compartment into salt solution compartment. Pressure heas in the salt solution compartment continue to rise until it reaches a value represented by the osmotic pressure of the solution. Then flow of water stops. In the same chamber divided by the osmotic membrane , if increasing pressure is applied on the salt solution compartment in the direction of the arrow , then the first drop of pure water flows in the direction of the arrow from the solution compartment to the pure water compartment when the applied pressure equal the osmotic pressure value of the solution. The applied p must be much greater than the osmotic pressure.	
2	**Attempt ant four**	16
2-a	**Classifications of boilers(any 4)** 1.**Use** a. stationary b. mobile 2. **Tube contents** a. fire tube boiler b. water tube boiler 3**. Tube shape and position** a. Tube shape (Form) –i. Straight ii. Bent iii. sinuous	1 mark each

	b. Inclination(position) – i. horizontal ii. Inclined iii. Vertical 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 wastergaes c. electrical energy d. nuclear energy	
2-b	**Water tube boiler** **Babcock and Wilcox boiler:**	4

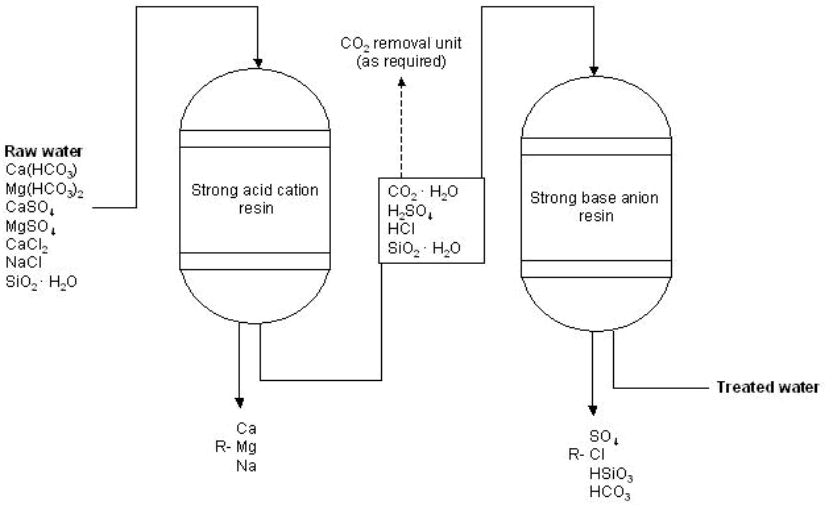
		
2-c	**Process air, instrument air and compressed air:** **Process air:** The air used in different chemical process (reaction and utility) is process air. The air should be dried and purified. **Instrument air:** It is used in instrumentation and tools. The air should be of required pressure, dried and free from any moisture, impurities and traces of oil. **Compressed air:** It is required for different purpose in chemical industries. It is used in chemical processes,, to avoid any side reactions, the air is dried and purified.	4
2-d	**Thermic fluid used (any 4)**	1 mark each

	Thermic fluid	Temp. Ranges (deg. F)
1	Dowtherm A	53.6 – 495.8
2	Dowtherm E	-6.7 to 352
3	Therminol FR	50-600
4	Oil mobiltherm 600	20(pour pt.) to >600
5	Oil Mobiltherm light	-20(pour pt.) to >400
6	Hydrotherm 750-200	5 (pour pt.) to ---

2-e **Instrument air:** 4



2-f	**Humidification:** i)if unsaturated air is passed through a spray of continuously recirculated water the specific humidity will increase while the dry bulb temp. decrease .this is the process of adiabatic saturation or evaporative cooling . ii)If water is added to air without any heat supply the state of air changes adiabatic along a constant enthalpy line - h - in the Mollier or psychrometric chart. The dry temperature of the air decreases. **Dehumidification:** i)The process in which the moisture or water vapor or the humidity is removed from the air keeping its dry bulb (DB) temperature constant is called as the dehumidification process. ii)This process is represented by a straight vertical line on the psychrometric charts starting from the initial value of relative humidity, extending downwards and ending at the final value of the relative humidity. Like the pure humidification process, in actual practice the pure dehumidification	2 2
3	**Attempt any four**	16
3-a	Ion exchange process:	2 marks for diagram



2

Description:

In this process, hard water is passed through cation exchanger which removes all the cationslike Ca^{++}etc and equivalent amount of H^+ ions are released from this column to water. After cationexchangrer 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:

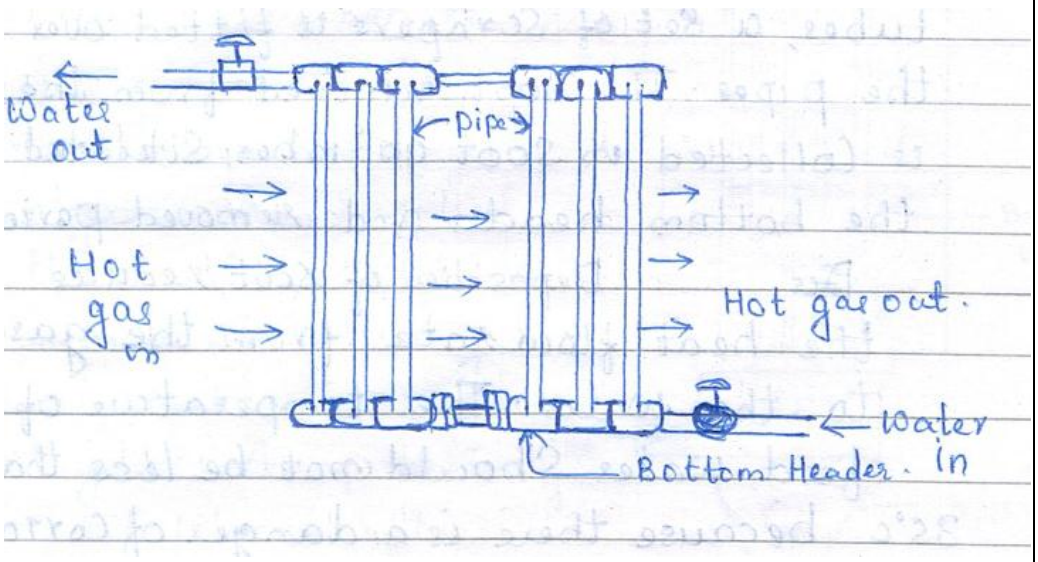
These are capable of exchanging cations in water by hydrogen ions. The resins such as sulphonated coals, tannin formaldehadereprented as RH2 are the example. Their exchange reaction with cations can be reprented as

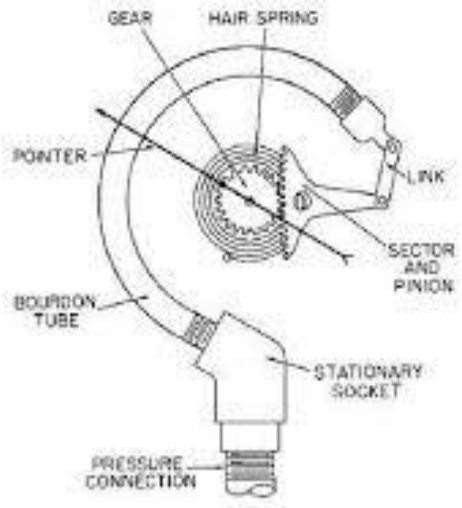
$RH_2 + Ca^{++} \rightarrow RCa + 2\,H^+$

These cation exchanges when exhausted can be regenerated by acid solution

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

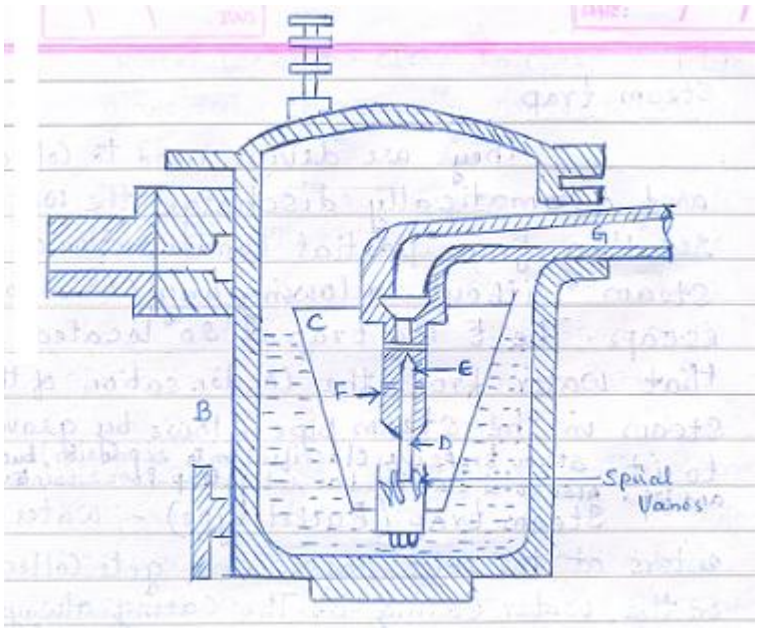
	Anion exchanger resins: These are capable of exchanging anion in water by hydraulic ion. The functional group in anion exchangers are $-N(CH_3)_2^+$, $OHNH_2$. The $N(CH_3)_2^+$ and –OH group are stable and react fast. These exchangers are reprented by $R(OH)_2$ $R'(OH)_2 + SO_4 \rightarrow R'SO_4 + 2\ OH$ Anion when exhausted regenerated by alkali solution. $R'SO_4 + 2\ NaOH \rightarrow R'(OH)_2 + Na_2SO_4$	
3-b	**Classification of refrigerants:** A. National Refrigeration Safety Code, USA classifies all the refrigerants into 3 groups 1. Group 1 refrigerants (safest) Ex. CCl_3F, 2. Group2 refrigerants (toxic and somewhat inflammable) Ex. Ammonia, methyl chloride 3. Group3 refrigerants (Inflammable refrigerants) Ex. Butane, ethane 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 Ex. CCl_3F, CCl_2F_2 and secondary refrigerants	4
3-c	**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. From the water inlet water goes to the bottom boxes and rises up in the vertical pipes into the top boxes. From the top boxes it goes to the pipe from where it goes to the water space of the boiler via check valve.	2

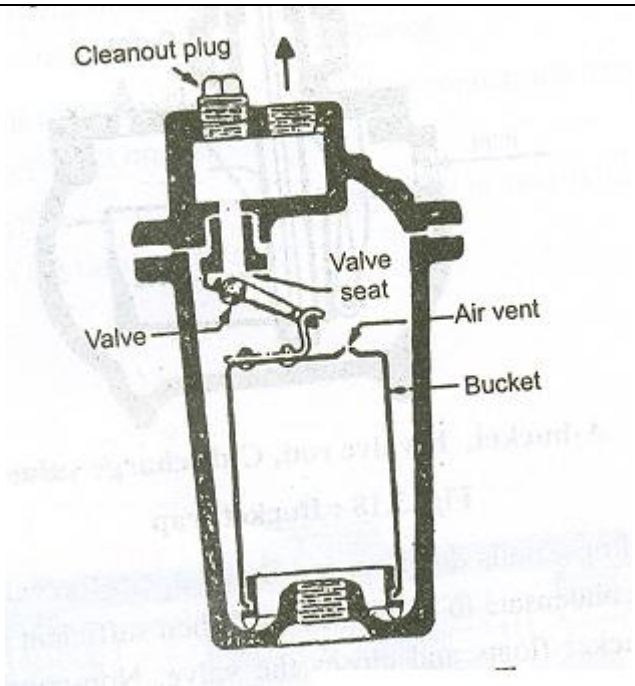
		2
3-d	**Boiler Act** **(i)Certificate of renewal:** After generally 12 months. If boiler is transferred from one state to another. If some accidents is occurs. If some alteration is done in boiler parts , etc. **(ii)Boiler accident:** In case of boiler accident, the occupier shall inform the inspector with full details of the same. The inspector shall carry out investigation and decide whether to permit the usage of boiler in future and if so , then at what working pressure. The inspector shall inform the chief inspector about his investigations.	2 2

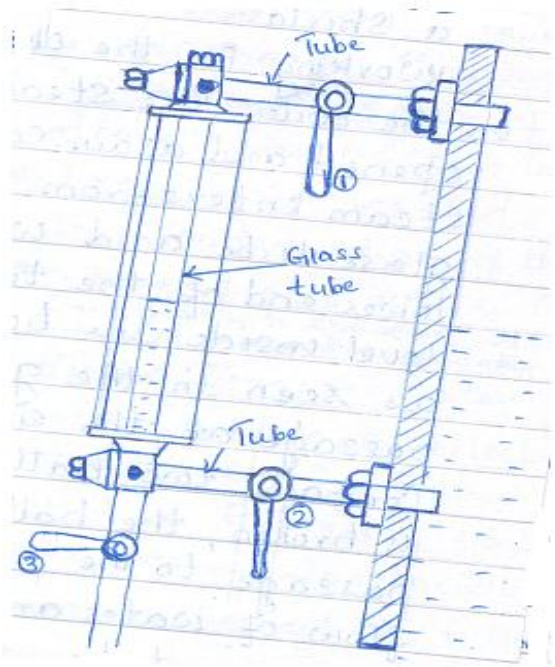
3-e	T1 = 35 + 273 = 308 K T2 = -20 + 273 = 253 K C.O.P. = T2/(T1-T2) = 253/(308-253) = 4.6 C.O.P = **4.6**	1 1 2
3-f	**Pressure Gauge:** It is used to indicate the steam pressure of the boiler **Bourdon Pressure Gauge:**   Spring tube ,elliptical in cross section made high quality phosphor bronze, one open end is connected via the hollow block and the other end is closed. Hollow solid block communicating the stem space via U tube siphon Link connecting the closed loose end of spring to the quadrant. Quadrant with teeth cut on the side opposite to which link is connected. Point for the quadrant so located that displacement of link connection is magnified the motion of the closed end of the spring is modified. Pointer mounted on the spindle fixed to the pinion, which moves on the graduated scale as the pinion moves.	1 3

	Pinion with spindle meshing with the toothed quadrant. The gauge is connected to the boiler steam space through U tube syphon	
4	**Attempt any four**	16
4-a	**Different sources of water are**: 1. Surface water a. Rain water b. River water c. Lake water d. Sea water 2. Underground water	4
4-b	**Boiler corrosion by dissolved oxygen:** Dissolved oxygen can destroy the protective hydrogen film that can form of many metals and oxidize dissolved ions into insoluble forms. Deposits of rust in a plumbing system is such an example of differential aeration cells and accelerate corrosion. 1. Corrosion due to dissolved oxygen (DO) $2\,Fe + 2\,H_2O + O_2 \longrightarrow 2\,Fe(OH)_2\downarrow$ $4\,Fe(OH)_2\downarrow + O_2 \longrightarrow 2\,[Fe_2O_3.2H_2O]\downarrow$ Ferrous hydroxide — Rust	2 2
4-c	**Ammonia is commonly used in industry**: Because of its low volumetric displacement,low cost ,low weight of liquid	2

	refrigerant per ton og refrigeration and high efficiency. **Properties:** It is toxic, flammable, irritating and food destroying No effect on lubricating oil **Application**: In cold storage, ice manufacturing plants,	½ mark each for any 2 ½ mark each for any 2
4-d	**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-e	**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	2 2

	temperature . It can be calculated by Q=mλ	
4-f	**Bucket type steam trap:**  B-casing C-bucket D- spindle E- Valve F- Seat G- exit pipe **OR** **Inverted bucket trap:**	4

		
5	**Attempt any four**	16
5-a	**Water level indicator:** **Principle:** When the cocks are opened, the pressure exerted inside the boiler and sight glass tube becomes equal and thereby indicating the level of water inside the boiler. **Construction**	1



1- steam cock, 2-water cock, 3-draincock

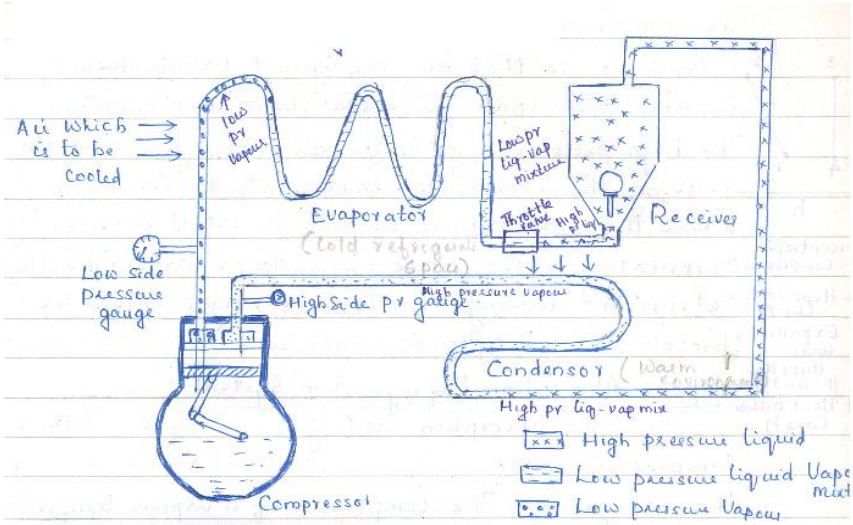
Water level indicator indicates the level of water in the boiler drum and warns the operator if by chance the water level goes below a fixed mark so that corrective action may be taken in time to avoid any accident.

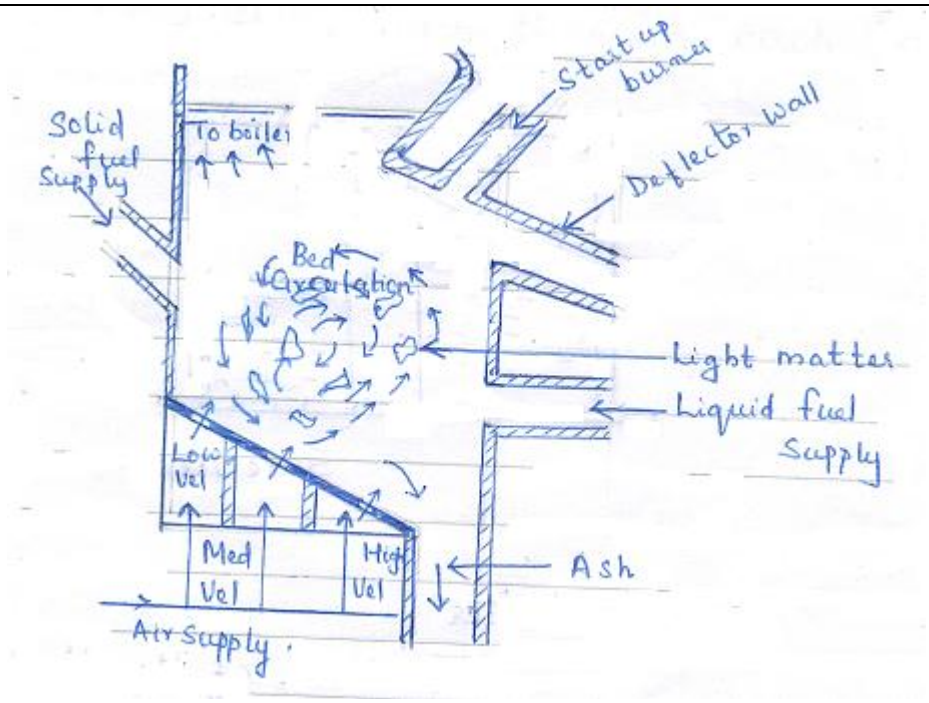
It consists of three cocks and a glass tube. The steam cock 1 keeps the glass tube in connection with the steam space and cock 2 puts the glass tube in connection with the water space in the boiler. The drain cock 3 is used to drain out the water from the glass tube at intervals to ascertain that the steam and water cocks are clear in operation. 1.5

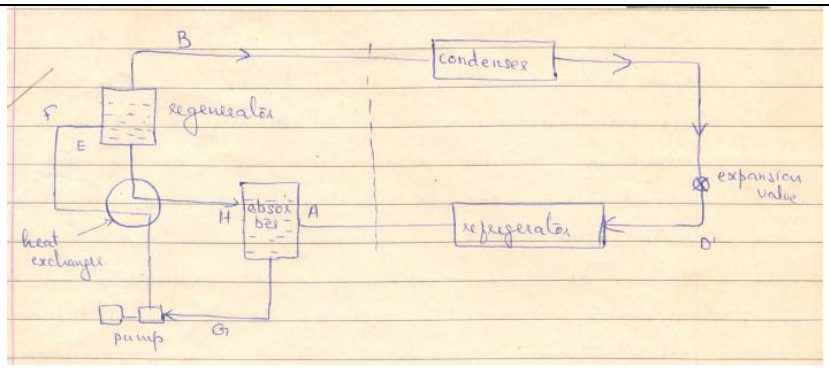
Working: The steam and water cocks are opened and the drain coke is closed. The steam enters from the upper end of the glass tube and water enters from the lower end of the tube, so the water level inside the boiler will be the same as seen in the glass tube. 1.5

5-b	**Inspection of boiler:** Boiler is inspected before the certificate for its operation is given to its employer. Before inspecting the boiler, It is cleaned. All fittings, such as burners, stokers, etc are removed. 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
5-c	**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 -10^0C **Application:** 1. Used in air-conditioning units. 2. Used in freezing units 3. Used for industrial low temperature refrigeration as low as -90 deg.C	1 mark each for any two properties 1 mark each for any two application
5-d	**Definition:** **(i) Foaming:** It is the phenomenon of formation of foam or bubbles on surface of water which do not break easily. (ii) **Coefficient of Performance**.(COP): It is the ratio of heat removed from the system (Q) to the work supplied to	1 1

	achieve the heat removal (W). COP = Q / W **(iii) 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. **(iv) Demineralization:** It is a method for treatment of water by which all the impurity ions present in the water are removed.	1 1
5-e	**Vapour compression refrigeration cycle:** The vapor-compression uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere. Figure shows a typical, single-stage vapor-compression system. All such systems have four components: compressor, condenser, thermal expansion valve, and an evaporator. Circulating refrigerant enters the compressor and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed vapor is then in the thermodynamic state known as a superheated vapor and it is at a temperature and pressure at which it can be condensed with either cooling water or cooling air. That hot vapor is routed through a condenser where it is cooled and condensed into a liquid by flowing through a coil or tubes with cool water or cool air flowing across the coil or tubes. This is where the circulating refrigerant rejects heat from the system and the rejected heat is carried away by either the water or the air .The condensed liquid refrigerant next routed through an expansion valve where it undergoes an abrupt reduction in	2

	pressure. The cold mixture is then routed through the coil or tubes in the evaporator. A fan circulates the warm air in the enclosed space across the coil or tubes carrying the cold refrigerant liquid and vapor mixture. That warm air evaporates the liquid part of the cold refrigerant mixture. At the same time, the circulating air is cooled and thus lowers the temperature of the enclosed space to the desired temperature. The evaporator is where the circulating refrigerant absorbs and removes heat which is subsequently rejected in the condenser and transferred elsewhere by the water or air used in the condenser. To complete the refrigeration cycle, the refrigerant vapor from the evaporator is again a saturated vapor and is routed back into the compressor.  ***(Any other type of refrigeration cycle should be given due consideration.)***	2
5-f	**Fluidized bed boiler:**	2

	 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
6	**Attempt any TWO of the following**	16
6-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 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	4 4
6-b	From steam table, corresponding to a temperature of 15^oC , h_f = 62.9 KJ/ Kg	

	h_{fg} = 2466.1 KJ/ Kg S_f = 0.224 KJ/ KgK S_{fg}= 8.559 KJ/ KgK Dryness fraction is 0.8 Specific enthalpy of steam = $h_f + x\, h_{fg}$ = 62.9 + 0.8* 2466.1 = = **2035.78 KJ** Specific entropy of steam = $S_f + xS_{fg}$ = 0.224 + 0.8*8.559 **= 7.0712 KJ /K**	4 2 2
6-c	DBT = 25^0C WBT = 15^0C (i)From psychrometric chart, corresponding to DBT = 25^0C & WBT = 15^0C, read from the relative humidity curve where these two points meet. Relative humidity = **32%** (ii)From psychrometric chart, find the intersecting point of DBT = 25^0C & WBT = 15^0C. From there draw a horizontal line to saturation temperature line to get the dew point temperature. Dew point temperature **= 6-7^{0}C**	2 3 3