WINTER-16 EXAMINATION

Model Answer

Subject code 17425

Important Instructions to examiners:

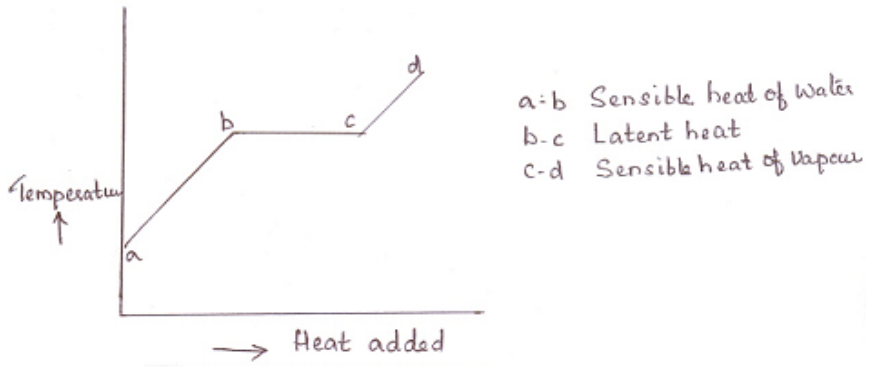
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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-i	**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	2
1a-ii	**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 which do not break easily.	1 1

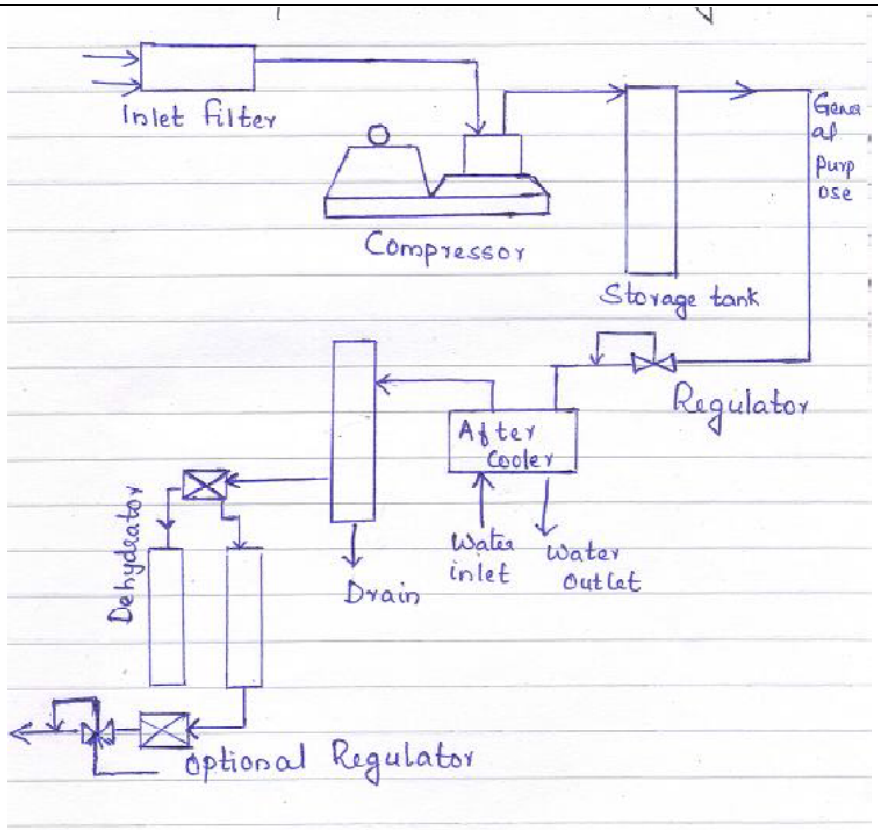
1a-iii	**Coefficient of Performance**.(COP): working performance of any machine is usually expressed by output/input ratio known as efficiency. In refrigeration it is denoted by C.O.P. (β). COP= refrigeration effect/ work input to produced R.E. β =RE/W	2
1a-iv	**Dryness fraction** : The fraction of steam 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
1a-v	**Enthalpy of superheated 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 superheated steam at that pressure.	2
1a-vi	**Compressed air** : High pressure air obtained from a compressor is known as compressed air. Compressed air is used in instrumentation purpose . It is also used in chemical process such as oxidation etc.	2
1a-vii	**Thermic fluid used for heating and cooling(any 4)** **1.**Dowtherm A 2.Dowtherm E 3.Therminol FR 4.Oil mobiltherm 600 5.Oil Mobiltherm light	½ mark each

<table>
<tr><td></td><td>6.Hydrotherm 750-200</td><td></td></tr>
<tr><td>1 b</td><td>Attempt ant two</td><td>8</td></tr>
<tr><td>1b-i</td><td>Comparison between Zeolite and lime soda process:
<table>
<tr><th>Zeolite Process</th><th>lime soda process</th></tr>
<tr><td>Residual hardness is 10 to15 ppm</td><td>Residual hardness is 15 to50 ppm</td></tr>
<tr><td>The quantities of sodium salts are increased</td><td>The quantities of sodium salts dissolved are lower</td></tr>
<tr><td>Cost of equipment and material is higher</td><td>Cost of equipment and material is lower</td></tr>
<tr><td>Operating expenses are lower</td><td>Operating expenses are higher</td></tr>
<tr><td>Not suitable for acidic water because zeolite undergoes disintegration</td><td>Can be used for any type of water</td></tr>
<tr><td>Plant occupies less space</td><td>Plant occupies less space</td></tr>
<tr><td>Water must be free from suspended impurities</td><td>Water containing suspended impurities can be used</td></tr>
<tr><td>Soft water obtained contains more dissolved salts</td><td>Soft water obtained contains more dissolved salts</td></tr>
<tr><td>Zeolite can be reused</td><td>Lime soda is used in the process</td></tr>
</table></td><td>1 mark each for any 4</td></tr>
<tr><td>1b-ii</td><td>Refrigeration effect: In gas cycle, refrigeration effect is the product of specific heat of gas and rise in temperature of gas in low temperature side.
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</td><td>2

2</td></tr>
<tr><td>1b-iii</td><td>1)Enthalpy of water :
The amount of heat absorbed by 1 kg. of water to heat it from freezing point (</td><td>2</td></tr>
</table>

	0^oC) to the boiling point is known as enthalpy of saturated water. **2) Enthalpy of evaporation** It is the amount of heat required to convert one kilogram of water at a given temperature and pressure into steam at the same temperature and pressure.	2
2	**Attempt ant four**	16
2-a	**Salts causes temporary hardness:** Bicarbonates of calcium and magnesium **Salts causes permanent hardness:** Chlorides and sulphates of calcium, magnesium or other heavy metals.	2 2
2-b	T1 = 40+ 273 = 313 T2 = -15 + 273 = 258 C.O.P. = T2/(T1 - T2) = 258 / (313- 258) = 4.69	1 1 1 1
2-c	**Formation of steam at constant pressure.**  Consider a cylinder fitted with a frictionless piston .Assume there is one kg of water initially at temperature 0^0Cin the cylinder. The piston exerts a constant pressure P bar. Let heat be supplied to water in the cylinder. The temperature	4

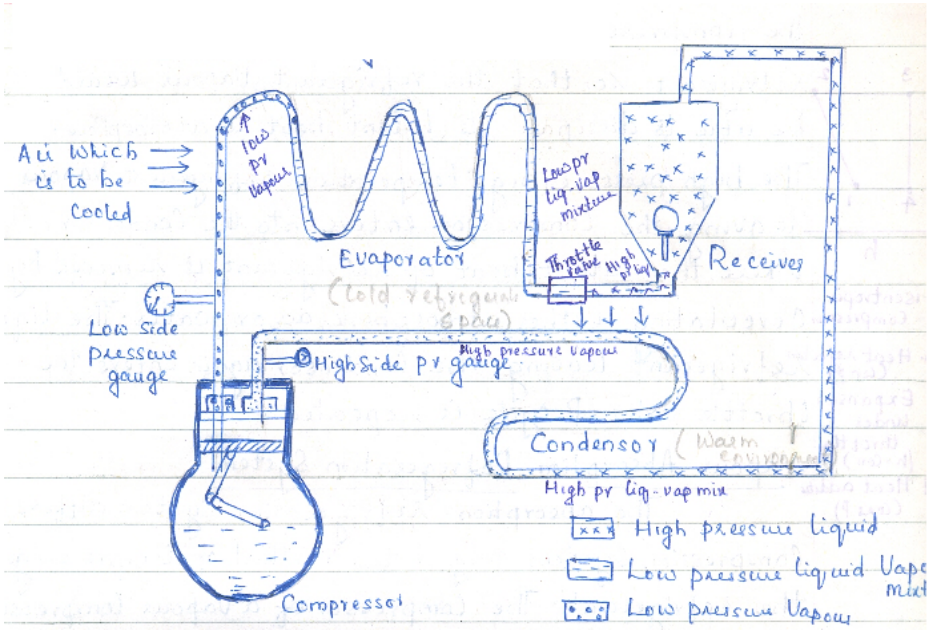
	of water will rise until the water boils at a temperature known as saturation temperature which depends upon the pressure in the cylinder. Steam begins to form and the contents of the cylinder will be a mixture of steam and water known as wet steam. When all the water including those particles of water held in suspension is evaporated, the steam is said to be dry and is known as dry saturated steam. As heating continues further, the temperature of steam begins to rise again and steam is now known as superheated steam and behaves more or less as a perfect gas.	
2-d	**(i) Specific 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. OR 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	2 2
2-e	**Instrument air:**	4



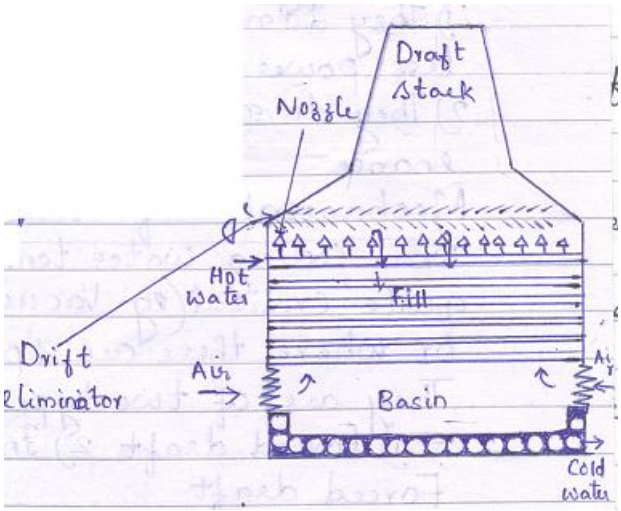
Air is passed through a filter to remove suspended impurities. The filtered air is

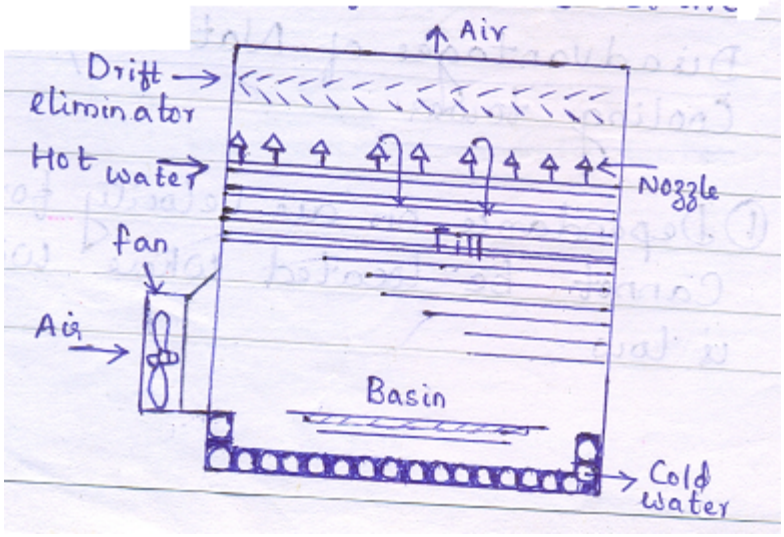
supplied to the compressor. Discharge from the compressor will be at a pressure of 100 to 150 psi, which is stored in a storage tank. When required it is passed through a regulator and then through an after cooler to remove the heat. It is then passed through a stone filter to remove traces of oil if 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-f	**Bad effects of scale and sludge:** Scales are hard and bad conductor of heat so when scales are formed, much heat is wasted and regular supply of steam is stopped. But if regular supply of steam is maintained, then extra heat will be given and hence extra amount of fuel will be required. So there will be wastage of fuel. Overheating of boiler results in damage of boiler and shorter boiler life.	4
3	**Attempt any four**	16
3-a	**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 pressure.	2

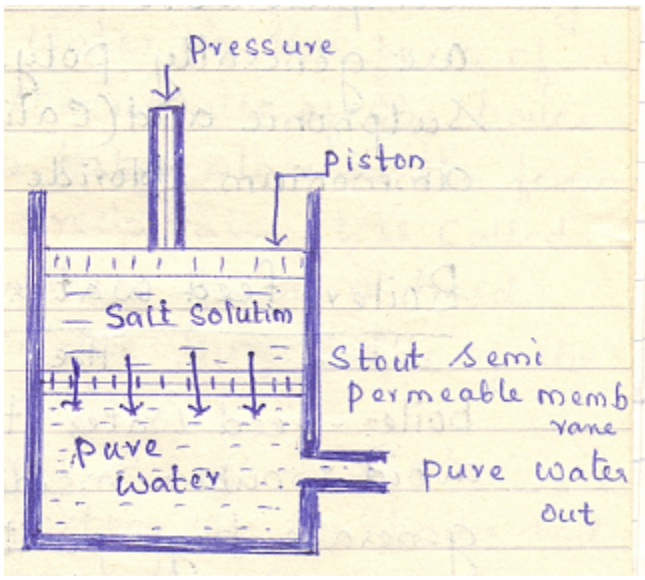
	The cold mixture is then routed through the coil or tubes in the evaporator. A fan circulates the warm air in the enclosed space across the coil or tubes carrying the cold refrigerant liquid and vapor mixture. That warm air evaporates the liquid part of the cold refrigerant mixture. At the same time, 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.  	2
3-b	**Steam trap:**	2

	They are used to collect and automatically discharge the water resulting from partial condensation of steam without allowing any steam to escape. **Water level indicator:** 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.	2
3-c	**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-d	**Cooling towers:** i) Natural draft atmospheric spray tower	2 marks for types and 2

	ii) Natural draft deck- type tower iii) Forced draft cooling tower iv) Induced draft cooling tower  The atmospheric towers depend on prevailing wind for air movement. The natural draft design ensures more positive air movement even in calm weather by depending upon the displacement of the warm air inside the tower by the cooler outside air. Fairly tall chimneys are then required. Both these tower types must be relatively tall in order to operate at a small wet bulb temperature approach. Natural draft equipment is used where the humidity is usually low, air temperatures are generally low. **Forced draft cooling tower**:	marks for description of any one type

	 **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 m/min is recommended with a flow of 100 to 190 cu.m. per minute per tone of refrigeration capacity.	
3-e	**Application of compressed air:** i)Cleaning automobiles and workshops. ii) Starting I.C. engine. iii) Spraying fuel in high speed diesel engine. iv)Spraying paints in paint industry. v)Construction of bridges, roads, dams, structural work , sewage and tunnels vi) Cooling of large buildings. vii)Operation of pneumatic drills, wrenches, air motors, hammers, also for riveting and tightening nuts etc.	1 mark each for any 4

	viii) Supercharging I.C. engine and in working of gas turbine plants	
3-f	**Classifications of boilers:** 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 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	4

	b. forced circulation 6. Heat source a. Fuel b. hot wastergaes c. electrical energy d. nuclear energy	
4 a	**Attempt any four**	16
4-a	**Reverse Osmosis:**  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	4

	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.	
4-b	**Properties of ideal refrigerant:** Properties of ideal refrigerants: i)The boiling point should be low.	½ mark each

ii)Condensation pressure should not be more

. iii)Critical temp. should be low.

iv)The latent heat of vaporization should be low.

v)specific heat of liquid should be low.

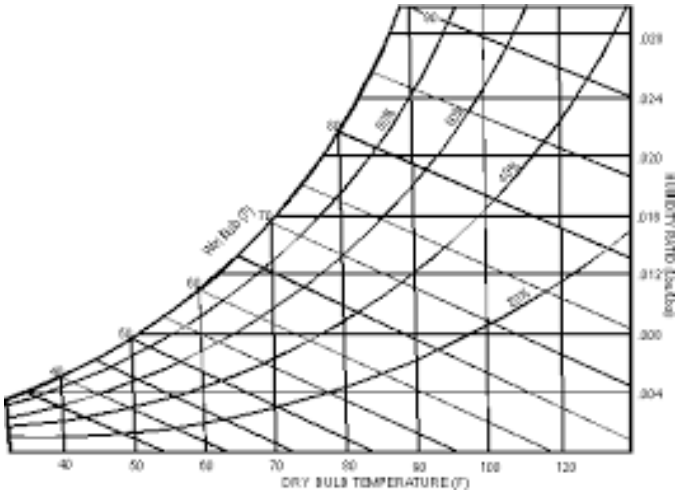
vi)it should not have any corrosive action with system materials.

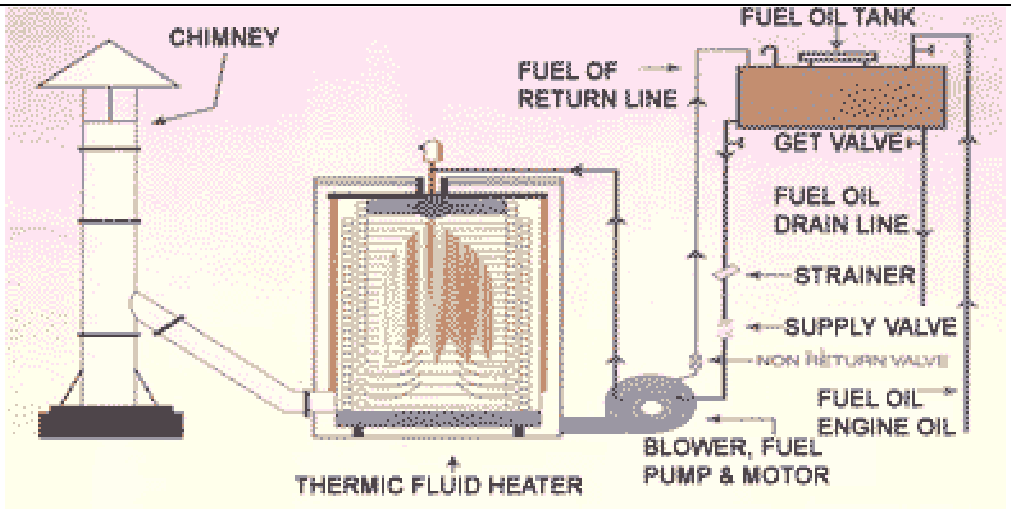
vii)it should be nonflammable and non-explosive

viii)it should be non-toxic

4-c **Water tube and fire tube boiler**: — 1 mark each for any 4

fire tube boiler:	**water tube boiler:**
In Fire-tube boilers hot flue gases pass through tubes and water surrounds them.	In Water-tube boilers water passes through tubes and hot flue gasses surround them.
These are operated at low pressures up to 20 ba	The working pressure is high enough, up to 250 bar in super critical boilers.
The rate of steam generation and quality of steam are very low, therefore, not suitable for power generation.	The rate of steam generation and quality of steam are better and suitable for power generation.
It requires more floor area for a given output.	It requires less floor area for a given output
Load fluctuations cannot be handled.	Load fluctuations can be easily handled.

	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, locom	
4-d	**Psychrometric chart**  The dry bulb temp. is indicated by vertical lines drawn parallel to the ordinate. The mass of water vapour in kg per kg of dry air is drawn parallel to the abscissa for different valued of dry bulb temp. Pressure of water vapour in mm of Hg is shown in the scale at left and is the absolute pressure of steam. Dew point temp. Re shown in the scale on the upper curved line. Constant RH Lines in per cent are indicated by marking off vertical distances between the saturation line or the upper curved lines and the base of the chart Uses: The psychrometric chart are prepared to represent graphically all the necessary moist air properties, used for air conditioning calculations. The values are based on actual measurements verified for thermodynamic consistency	4
4-e	**Thermic fluid heater**	4



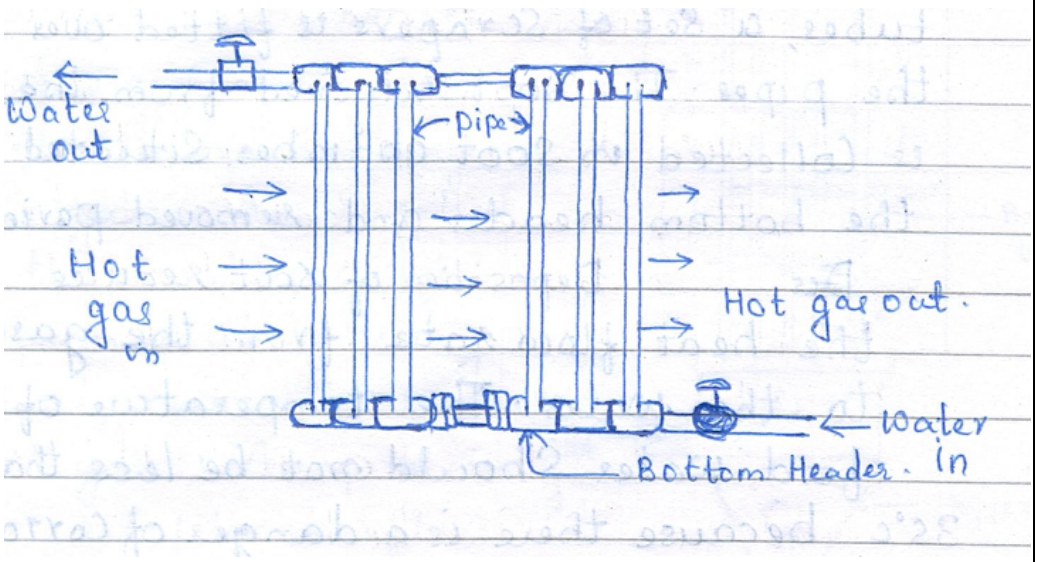
thermic fluid heater boiler has been widely used in various applications for indirect heating process. By using petroleum fluids as heat transfer medium, these heaters provide constant temperature. Combustion system consists of fixed grate with mechanical draft arrangements.

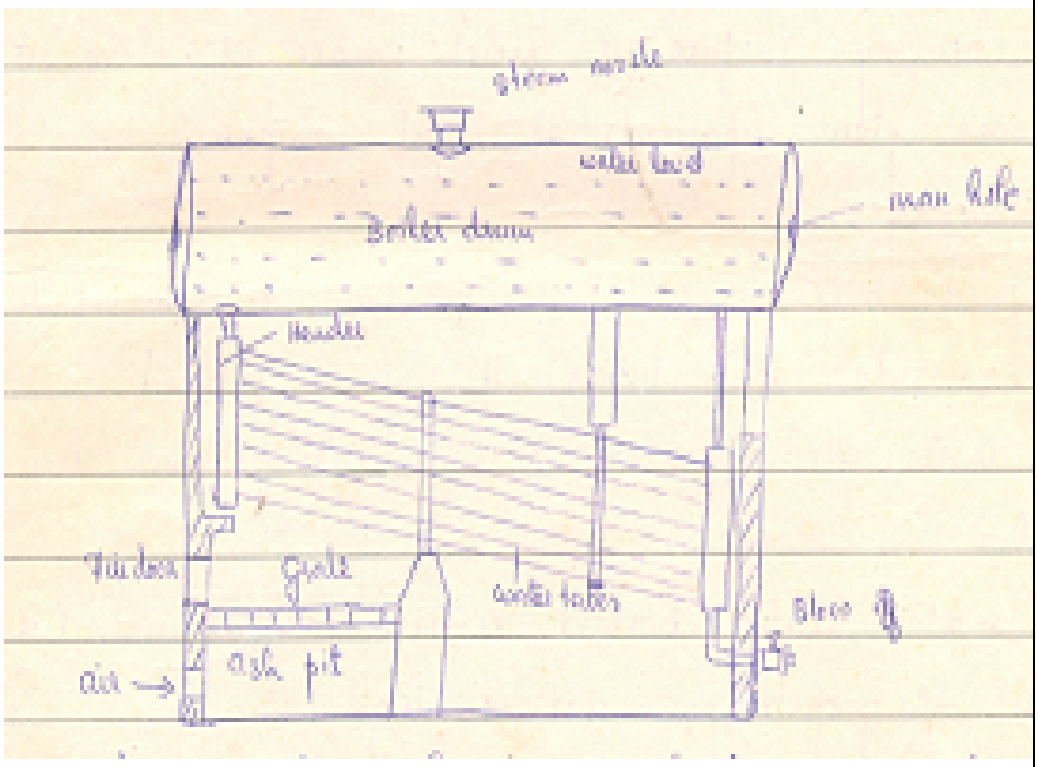
Thermic fluid heater boiler modern with oil-fired consists of double coil, construction of three passes and is fitted with pressure jet system. Thermic fluid, which acts as a heat carrier, heated in the heater and circulated through the user's equipment. Fluid transfer heat through heat exchanger to the process, then the fluid is returned to the heater.

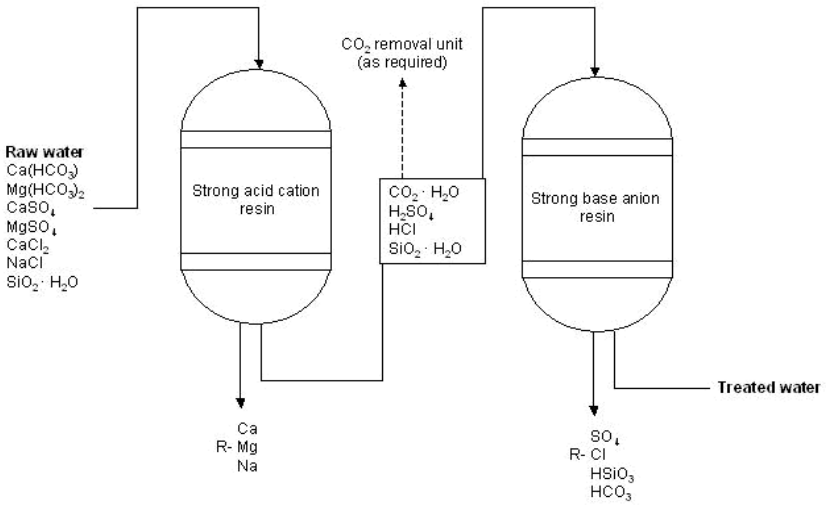
Thermic fluid flow at the user end is controlled by a control valve that is pneumatically operated, based on the operating temperature. Heater operates at high fire or low fire depending on the return oil temperature which varies

	depending on system load. The advantages of thermic fluid heater are: Closed operating system with minimum losses as compared to steam boilers. Operating system is not pressurized even for temperatures around 250 C compared to the needs of the steam pressure of 40 kg/cm2 in a similar steam system. Automatic control settings, which provide operational flexibility. Thermal efficiency is good because there is no heat loss caused by blowdown, discharge condensate and flash steam. The overall economic of thermic fluid heater boiler depend upon the specific application and the reference basis. Thermic fluid heater boiler with coal-fired which has range thermal efficiency 55-65%. Thermic fluid heater boiler is most comfortable to use than the most common boiler. Incorporation of heat recovery devices in the exhaust gas will further enhance the thermal efficiency.	
4-f	**Applications of refrigeration**: 1. Comfort air conditioning of auditorium, hospital, offices, residences etc. 2. 2. Manufacture and preservation of medicine 3. 3. Preservation of blood and human tissues 4. 4. Storage and transportation of food stuff such as meat, fruit, fruit juice, vegetables etc. 5. Ice cooling of concrete for dam.	4
5	**Attempt any four**	16

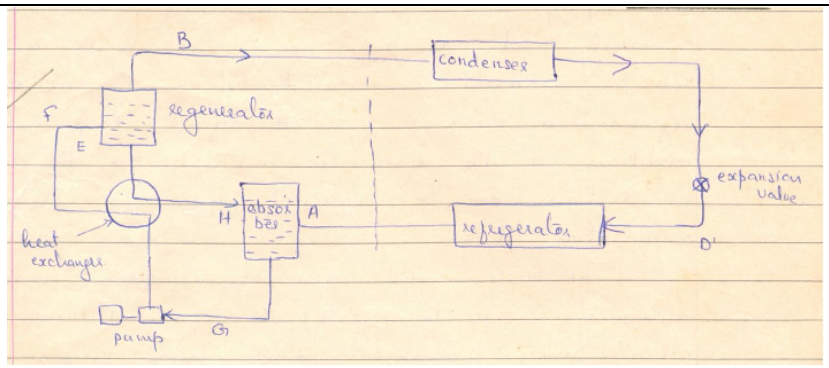
5-a	**Classification of refrigerants:** A. National Refrigeration Safety Code, USA classifies all the refrigerants into 3 groups 1.Group 1 refrigerants (safest) 2. Group2 refrigerants (toxic and somewhat inflammable) 3. Group3 refrigerants (Inflammable refrigerants) B. National board of Fire Underwriters 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
5-b	**Different boiler mountings:** 1. Water gauge or water level indicator 2.Pressure gauge 3.Fusible plug 4.Safety valve **Different boiler accessories :** 1. Air preheater 2. Super heater 3. Economizer	2 2
5-c	**Economiser** **Construction**: It consists of groups of vertical cast iron pipe. The tubes are fitted at their two ends to the cast iron boxes, at the top and the bottom. These are pressed hydraulically into the top and bottom boxes. The sides of the top boxes are machined and bolted together to form an air tight roof. All the tubes	2

	are enclosed within the brickwork of the economizer. There are two pipes outside the brickwork. **Working:** 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
5-d	**Humid heat:** It is the heat required to raise the temperature of unit mass of gas and the accompanying vapours through one degree at constant pressure. **Humid volume:** It is the volume of unit mass of dry gas and its accompanying vapour at the prevailing temperature and pressure.	2 2

5-e	**Babcock and Wilcox boiler** **Diagram:**  **Construction:** The drum is connected to a series of front end and back end headers by short riser tubes. A series of inclined water tubes are connected to these headers. A hand hole is provided in the header in front of each tube for cleaning and inspection of tubes. The hot gases from the furnace are forced to move upward between the water tubes by the baffles provided. **Working:** Feed water enters the front of the drum, passes to the back of the drum and then descends through the down comer and enters the headers. Water then	2 1 1

	enters the water tubes, moves upward through the inclined tubes and finally rises through the front riser tubes to the drum.	
5-f	**Sterilization of water:** **Definition:** the process of removing bacteria and microorganisms from water and making it safe for drinking is known as sterilization **Methods for sterilization of water:(any four)** 1. Boiling 2. Using chlorine 3. Ozonizing 4. Passing ultra violet light 5. Treating with potassium permanganate	2 ½ mark each
6	**Attempt any TWO of the following**	16
6-a	**Ion-exchanger process:**  **Description:** In this process, hard water is passed through cation exchanger which removes	3

	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 $RH_2 + Ca^{++} \rightarrow RCa + 2H^+$ 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. $R'SO_4 + 2NaOH \rightarrow R'(OH)_2 + Na_2SO_4$	5
6-b	**Vapour Absorption system**	3

	 In absorption system the compressor in the vapor compression cycle is replaced by an absorber- generator assembly involving less mechanicalwork. Ammonia is the refrigerant and water is the absorbent.Ammonia vapor is vigorously absorbed in water. So low pressureammonia vapor from the evaporator comes in contact in the absorberwith a weak solution coming from the generator, it is readily absorbedreleasing the latent heat of condensation . The temperature of thesolution tends to rise, while the absorber is cooled by the circulatingwater , absorbing the heat of solution, Q_A and maintaining a constanttemperature. 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 ofwater, the ammonia vapor is given off from the aqua- ammonia solutionat high pressure and the weak solution returns to the absorber through apressure reducing valve. The heat exchanger preheats the strongsolution and cools the weak solution, reducing both Q_A& Q_G. Theammonia vapor then condenses in the condenser, is throttled by theexpansion valve, and then evaporates absorbing the heat of evaporationfrom the surroundings.	5
6-c	**(i) Boiler accident:** In case of boiler accident, the occupier shall inform the inspector with full	2

	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 **(ii)Duties of chief inspector:** The chief inspector shall 1. Maintain record of registered boilers. 2. Examine boiler inspection reports produced by inspector. 3. Decide whether to issue the certificate for the operation of boiler or not. 4. Supervise and control the work of inspectors. **(iii) Registration of boiler**: 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. (iv) **Certificate of renewal:** The certificate useful to the employer for using the boiler shall be renewed 1. After generally 12months 2. If the boiler is transferred from one state to another. 3. If some accident occurs or boiler pipes etc do not remain in safe conditins. 4. If some alteration are done in boiler parts.	2 2 2