MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

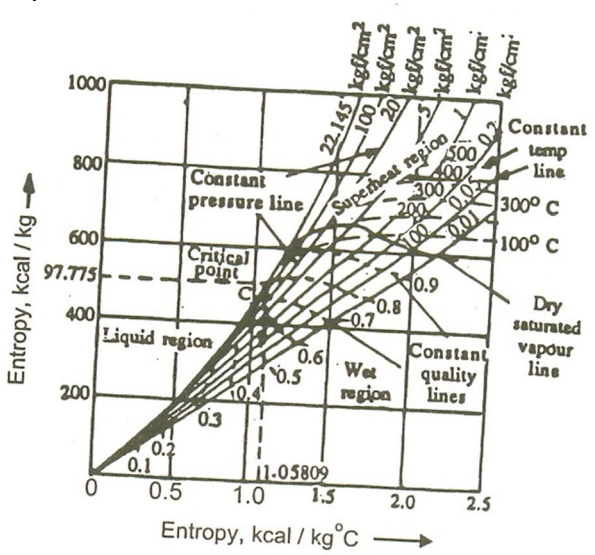
WINTER-12 EXAMINATION

Model Answer

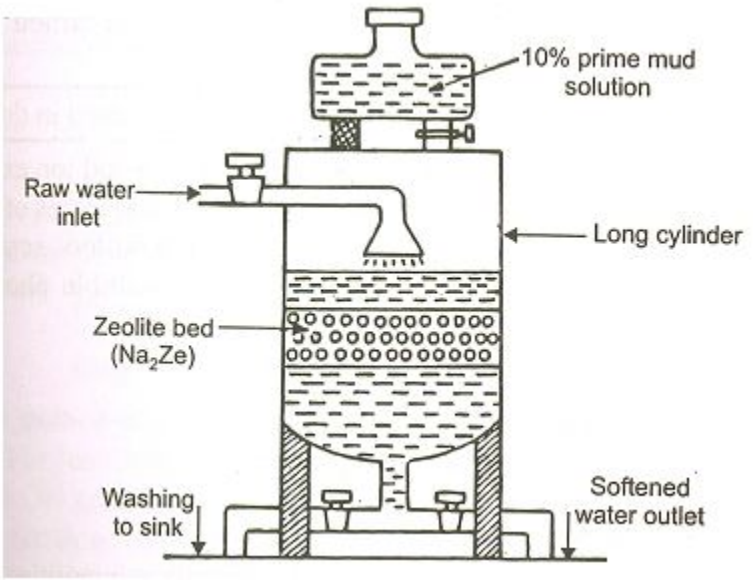
Subject code: PUT (12129)

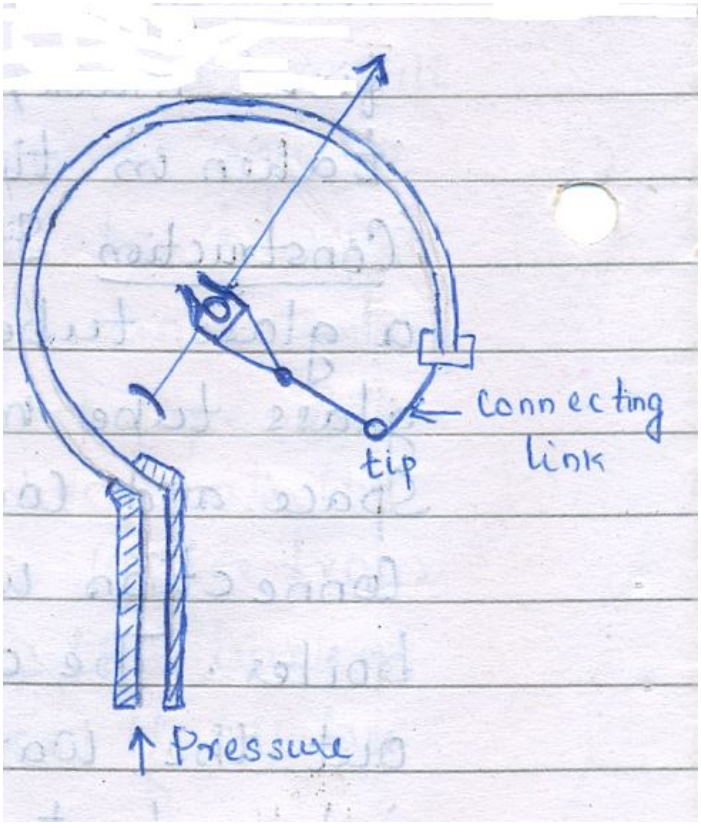
Question No:	Answer	Remark
1.(A)- (a)	**Gases dissolved in rain water** i) Carbondioxide ii) Oxygen iii) Hydrogen sulphide iv) Oxides of nitrogen and sulphurdiaoxide **Salt dissolved in rain water** i) Sodium ii) Potassium iii) Calcium iv) Magnesium v) Ammonia vi) Iron vii) Aluminium viii) Chlorides ix) Sulphates x) Bicarbonates xi) Nitrogen	1mark Any four, 1mark
(b)	Requisite of water for photographic filler : There should be sufficient supply of pure water which is colourless and absolutely free from suspended matter and metals such as iron, zinc and manganese	2 marks
(c)	Refrigerants used in refrigeration are : 1. Halocarbon compounds 2. Azeotropes 3. Hydrocarbons 4. Inorganic compounds	1mark each
(d)	Relative Humidity : It is the ratio of partial pressure of water vapour in a mixture to the saturation pressure of pure water at the same temperature of the mixture.	2 marks

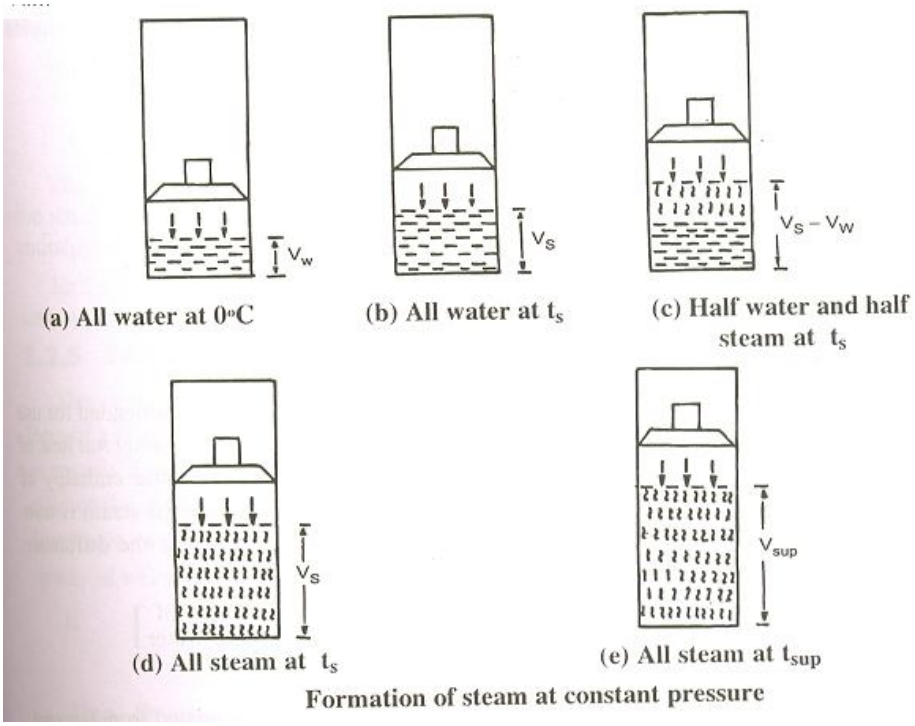
(e)	Uses of Air : 1. To drive compressed air engines used in coal mines. 2. To clean workshop, generators and machines. 3. To inject the fuel in cylinder of diesel engines. 4. To operate drills, hammers, paint sprayer. 5. For cooling furnaces. 6. For cooling of reaction taken place in chemical industries. 7. For cooling large boilers.	Any two 1mark each
(f)	Methods of softening of water are : 1. Lime soda process 2. Zeolite process. 3. Ion exchange process.	2 marks
(g)	Classification of insulators : 1. Organic thermal insulator e.g. Wool, cotton wool, wood pulp, silk etc. 2. Inorganic thermal insulator e.g. glass wool, asbestoses, rock-wool etc.	2 marks
(h)	Classification of boiler : 1. Based on use a) Mobile. b) Stationary 2. Based on tube content a) Fire tube boiler b) Water tube boiler 3. Based on tube shape and possition a) Straight b) Inclined 4. Based on furnace position a) Internally fired b) Externally fired 5. Based on circulation of water a) Natural b) Forced	2 marks
1.(B)- (a)	Duties of boiler inspector : 1. Confirmed all boilers are registered. 2. Make sure that all boilers are working according to the Boiler Act. 3. Check and examine boilers, their parts and mounting etc.	1mark each

	4. Advice the employer of boilers regarding the matters of boiler maintenance , cleaning etc.	
(b)	Mollier diagram : It is a graphical representation of steam tables in which specific entropy is plotted along the x axis and specific enthalpy along the y axis . The diagram is divided into two portions by a horizontal line termed as saturation curve. The lower portion contains the values of weight steam , where as the upper portion contains the value of super heated steam. A moilier diagram has the following lines. 1. Dryness fraction lines 2. Constant specific volume lines 3. Constant pressure lines 4. Constant temperature lines  	2 marks 2 marks
(c)	**Boiler mountings are :** 1. Water level indicator 2. Pressure gauge 3. Fusible plug 4. Level safety valve **Boiler accessories are :** 1. Pressure reducing valve 2. Steam trap 3. Feed pump 4. Super heater 5. Economiser 6. Steam separator	2 marks 2 marks

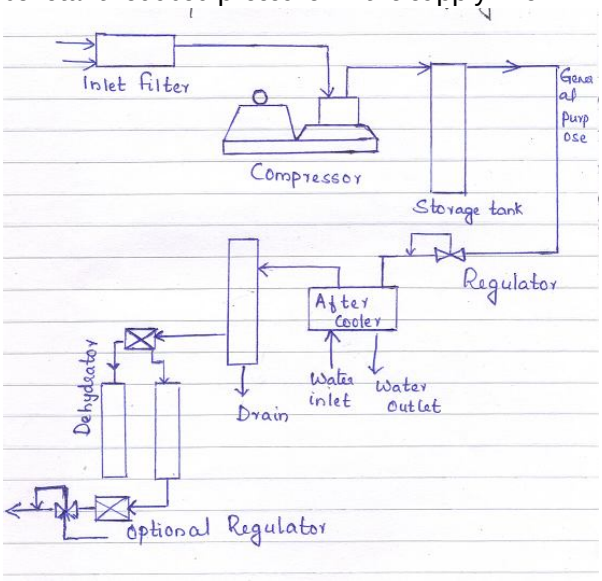
2. (a)	Zeolite process for water treatment : The chemical structure of sodium zeolite can be represented as $Na_2OAl_2O_3.SiO_2.H_2O$. These are capable of exchanging their sodium ions for multivalent ions of calcium and magnesium present in water. Hence , zeolite can be used for softening of water. The reactions taking place are: $Ca(HCO_3)_2 + Na_2Ze \rightarrow CaZe + 2\ NaHCO_3$ $Mg(HCO_3)_2 + Na_2Ze \rightarrow MgZe + 2\ NaHCO_3$ $CaSO_4 + Na_2Ze \rightarrow CaZe + Na_2SO_4$ $MgSO_4 + Na_2Ze \rightarrow MgZe + Na_2SO_4$ $CaCl_2 + Na_2Ze \rightarrow CaZe + 2\ NaCl$ $MgCl_2 + Na_2Ze \rightarrow MgZe + 2\ NaCl$ $FeCl_2 + Na_2Ze \rightarrow FeZe + 2\ NaCl$ $Mn(HCO_3)_2 + Na_2Ze \rightarrow MnZe + 2\ NaHCO_3$ **Regeneration of zeolites :** After some time, the zeolite is completely converted to calcium and magnesium zeolites. These zeolites cannot soften water i.e. it is exhausted. The zeolite can be regenerated and reused for softening of water. The supply of hard water is stopped and the exhausted zeolite is reclaimed by treating the bed with a concentrated brine solution. $CaZe + 2\ NaCl \rightarrow Na_2Ze + CaCl_2$ $MgZe + 2\ NaCl \rightarrow Na_2Ze + MgCl_2$ The washing containing higher proportion of $CaCl_2$ and $MgCl_2$ is led to drain and regenerated zeolite is used for softening of hard water. **Zeolite water softener :** These are of two types : (a) Gravity type, (b) Pressure type. Both the units operate on the same principle involving alternate cycle of softening and regeneration of zeolite. During softening hard water is passed over sodium zeolite bed when Ca^{++} and Mg^{++} ions are replaced by Na^+ from zeolite. Regeneration process consists of back washing, salting and rising of zeolite bed. **Description of lime soda process or Ion exchange process may be given Mark**.	1 mark 3 marks 2 marks

		2 marks
(b)	**Bell-Coleman cycle :** It is a modified ideal reversed Carnot cycle to make it more useful for practical purpose. It comprises a compression cylinder (air compressor) and an expansion cylinder (air motor). The work obtained from the air motor is used to help to drive the compressor. Thus external work required is reduced. The plant also comprises a cooler which contains a number of pipes through which air passes and the pipes are immersed in circulating cooling water. The cold air in the cold chamber comes in direct contact with the chamber and the pressure is also atmospheric. Consider that 1 kg. of air from the cold storage chamber is drawn in to the compressor cylinder during the suction stroke. Cold storage chamber may be initially at atmospheric condition of temperature and pressure. It is then compressed isentropically during the first part of compression stroke. Thus temperature is raised and pressure is raised . Further stroke of the piston expels the air at high pressure and temperature to the cooler. The cooler the air at constant pressure and the specific volume gets reduced. The temperature air falls to that of cooling water. The air at cooling water temperature and high pressure is drawn in the air motor during its suction stroke and then expanded isentropically to cold chamber pressure (Atmospheric pressure). The expansion results in a fall in temperature. Thus the temperature is reduced to very much below the cooling water temperature . By this method heat is being abstracted from cold storage chamber and is being rejected to the circulating cooling water. If the rate of heat abstraction from cold storage chamber is the same as heat input from stored stuff and through walls , the temperature can be maintain in the cold chamber.	3 marks 5 marks

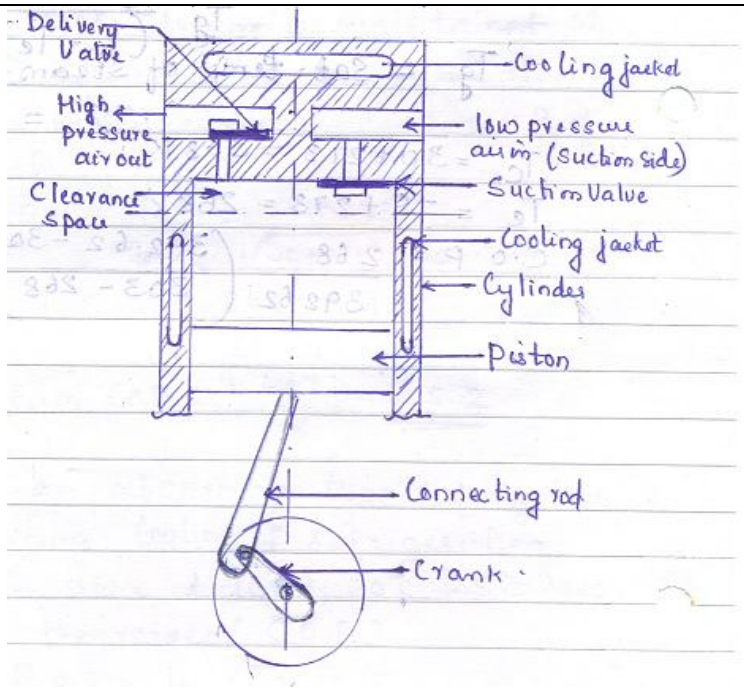
(c)	**Pressure gauge (Bourdon gauge)** : The function of pressure gauge is to indicate the steam pressure of the boiler. It is mounted in the front top of the shell. The dial is graduated to read pressure in Kgf/cm^2 gauge. Graduation normally extend to twice the pressure at which it is normally required to work. Bourdon Tube : Principle is that a tube having internal cross section that is not a perfect circle if bent or distorted , has the property of changing its shape with internal pressure variation. It consist of a tube which is formed by winding the tube to form a segment of a circle. One end of the tube is welded to a socket at the base through which pressure is fed in side the tube while the other is sealed by tip. When pressure is applied , its cross section tries to become more and more circular that causes straightening of the tube. Since one end of the tube is fixed , straightening causes the free end to deflect (Tip travel). The tip travel is than amplified and the pinion converted the amplified tip travel into proportional rotary motion of the pointer connected to the pinion. The pointer deflection can be red on the scale calibrated in term of pressure.  	2 marks 3 marks 3 marks

3. (a)	Formation of steam at constant pressure:  (a) All water at 0°C (b) All water at t_s (c) Half water and half steam at t_s (d) All steam at t_s (e) All steam at t_{sup} **Formation of steam at constant pressure**	2 marks
	During first stage of heating, the temperature of water will begin to rise until the water boils at temperature known as saturation temperature which depends upon the pressure in the cylinder. After the boiling temperature is reached, steam begins to be formed during which time, temperature remains constant. Until the point is reached at which all water converted into steam, the content of mixture will be steam and water known as wet steam. When all the water including those particles of water held in suspension will be 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 marks
(b)	Method of refrigeration use in industries are : 1. Air refrigeration 2. Vapour compression refrigeration 3. Absorption refrigeration Absorption refrigeration : Ammonia vapour is rigorously absorbed in water. So when low pressure ammonia vapour from the evaporator come 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,	1 marks

	while the absorber is cooled by the circulation 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 . Since the boiling point of ammonia is less than that of water, the ammonia vapour is given off from the 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 pre cools the weak solution. The ammonia vapour then condense in the condenser and than evaporates absorbing the heat of evaporation from the surrounding. **Any of above three may be given marks.**	3 marks
(c)	T1=303 K T2= 263 K β= T2/(T1-T2) = 6.575 One tonne of refrigeration is= 3.517KJ/s 10 tonnes = 10* 3.3.517 KJ/s= 35.17KJ/s= R.E β = R.E/W W= R.E/ β =5.349KJ/s Heat is rejected = R.E+W=40.519KJ/s = 145868.58KJ/h Power required = 5.349KJ/s(KW)	1 mark 2 marks 1 mark
(d)	**Humidification:** When dry air is contacted with a liquid surface, the air picks up water vapour from the water surface. This is known as humidification. During humidification, water surface becomes cool because it looses the latent heat due to water evaporation. Also there is sensible heat transfer from air which is at a higher temperature to water surface which is at a lower temperature. **Dehumidification:** If a warm vapour-gas mixture is contacted with a cold liquid, vapour will diffuse towards the liquid and the gas is said to be dehumidified.	2 marks 2 marks
(e)	The locomotive boiler is a horizontal, multitubular, natural circulation, internally fired, fire tube type of boiler. The principal feature of this boiler is to produce steam at a very high rate. It consist of a cylindrical steel shell having 1-5 m dia and 4m in length. The coal is fed into the fire box through the fire door and burns on grate. About 15% of tubes are of larger dia of 12.5 cm and remaining are of 4.5 cm dia. The barrel contains water around the tubes which is heated up by the flue gases and gets converted into steam. The heater is divided into two portions, one is the superheated steam chamber and the other is the saturated steam chamber. The steam pipe leads the steam from the regulator to the saturated steam chamber. It then leads the steam to the super heater tubes and after passing through these tuibes, the steam returns back to the superheated steam chamber. The superheated steam now flows through the steam pipes to the	3 mark

	cylinder one on each side. It is used to produce steam at high pressure	1 mark
(f)	Properties of an ideal refrigerant: 1. It should be non poisonous 2. It should be non explosive 3. It should be non corrosive 4. It should be non inflammable 5. It should be non toxic 6. It should bea stable gas 7. Leak should be easy to detect 8. Leak should be easy to locate 9. It should operate under low pressure 10. It should have a well balanced enthalpy of vaporization per unit mass. 11. A minimum difference between the vaporizing pressure and condensing pressure is desirable.	Any eight ½ mark each
4 a	Thermic fluid heater consists of burners, tube coils, armatures, safety and control panel etc. Heaters are provided by burners which are oil fired or gas fired or electrically heated. The thermic fluid is heated during the flow through the tubes. Heat is transferred to the oil by radiation from combustion chamber. The combustion gases get cooled when it passes through the space between the tubes. The thermal design ensures unlimited thermal expansion due to high fluid temperature.	4 marks
4 b	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.  	3 marks 1 mark

4 c	Advantages of water tube boilers over fire tube boilers. 1. Small drum size. 2. Since drum size is small, drum can be made very strong for very high pressures. 3. More effective heating area utilization. 4. Fuel is effectively used by multipass flow. 5. Generate high pressure steam. 6. Raises steam quickly and flow rate is high 7. Requires less space.	Any 4 points 1 mark each
4 d	Mineral oil is a liquid petroleum derivative. Properties: 1. Low viscosity 2. Colourless 3. Odourless 4. Tasteless 5. Hydrophobic 6. They will not disintegrate at high temperature. 7. Normally no need to be pressurized 8. Flash point remain unchanged after many hours of service. Uses: 1**. Industrial applications**: Used as non conductive thermal fluid, Can be employed in open systems, at high temperatures, the conventional mineral oils are used in closed systems up to 600^0F. 2.**Cosmetics** : Used in baby skin products, ointment, cold cream. **3.Preservatives** :For protecting metal tools and weapons from rusting, they are coated with mineral oil. **4.Medicine** : Used in internal and external therapeutic solutions. **5.Cleaning** : Used for removing oil stains.	Any four points ½ mark each Any 2 points , 1 mark each
4 e	Working: During the downward motion of the piston, the pressure inside the cylinder falls below the atmospheric pressure and the inlet valve is opened due to the pressure difference. The air is taken into the cylinder until the piston reaches bottom dead centre position. As the piston starts moving upwards, the inlet valve is closed and pressure starts increasing continuously until the pressure inside the cylinder is above the pressure of the delivery side which is connected to the receiver. At the end of the delivery stroke, small volume of high pressure air is left in the clearance space. The high pressure air left in the clearance space expands as the piston starts moving downwards and pressure of the air falls until it is just below the atmospheric pressure. The inlet valve opens as the pressure inside the cylinder falls below atmospheric pressure and air from outside is taken in and the cycle is repeated.	2 marks

		2 marks
4 f	Methods for removing scales. 1. By using scraper or piece of wood or wire brush 2. By giving thermal shock 3. By dissolving them by adding some chemicals. 4. By frequent blow-down operation Scales can be removed by dissolving them by adding some chemicals, If they are adherent and hard. Ie $CaCO_3$ scales can be dissolved by adding 5-10% HCl. $CaSO_4$ scales can be dissolved by adding EDTA, with which they form soluble complexes.	2 marks 2 marks
5 a	(i) Glass wool:- Properties (any one) 1.non combustible and fire proof 2. low electrical conductivity 3. Completely heat proof 4. does not absorb moisture or water. 5. Density is low 6. thermal conductivity is low 7. tensile strength is about 8 times more than steel Uses (any one) 1. Heat insulation purpose. 2. Being resistant to chemicals, glass wool is used for filtration of corrosive liquids like acids. 3. Electrical insulation 4. Sound insulation 5. In dust filters as dust filtering material 6. For manufacturing fibre glass (ii) Thermocole	1 mark 1 mark

	Properties(any one) 1.Quite strong,but light 2. Density is about 20kg/m^3 3. Thermal conductivity is about 0.27 Kcal/hrm^2 ^{0}C 4. Electrical conductivity is low 5. Resistance to ageing 6. Chemically inert 7. Shock proof Uses (any one) 1. In air conditioning and refrigeration 2. Being shock proof, it is used as packing material for delicate materials. 3. Decorative purpose 4. For protecting screens in radars.	1 mark 1mark
5 b	Safe working properties:(any six) 1. Low boiling point and freezing point 2. Low specific heat and high latent heat 3. Pressure required to be maintained in the evaporator and condenser should be low enough and must be positive. 4. High critical pressure and temperature. 5. Low specific volume. 6. High thermal conductivity. 7. Non-flammable, non toxic, non corrosive 8. Should not have any bad effect on the stored material or food when any leak develops in the system. 9. Must have high miscibility with lubricating oil 10. High C.O.P Refrigerant must have low specific heat and high latent heat. High specific heat decreases the refrigerating effect per Kg of refrigerant and high latent heat at low temperature increases the refrigerating effect per kg of refrigerant.	½ mark each 1 mark
5 c	**Fan** : it is used to handle large volume of gases at low pressure and produces gases at low pressure usually in the range of 30KPa **Blowers** : Used to handle volume of gases at low pressure and produces gases at medium pressure in the range of 800 KPa **Compressor**: used to handle gases at low pressure and high volume and produces gases at high pressure (in the range of 240 MPa)and low volume.	4 marks
5 d	(i) **Dry bulb temperature**: It is the temperature of the gas mixture measured with by an ordinary thermometer. (ii) **Wet bulb temperature**: It is the temperature measured by a thermometer whose bulb is covered by a wick fully wet with the same liquid existing in the vapour phase in the mixture. (iii) **Sensible heat:** It is the heat required to change the temperature of a substance within the same phase. (iv) **Latent heat**: It is the heat required to change the phase of a substance without any change in temperature.	1 mark 1 mark 1 mark 1 mark

5	e	(i)**Transfer of boiler** When a boiler is transferred from one state to another, permission is again sought from the Chief Inspector of new state for its installation and operation. (ii)**Boiler repairs** Before carrying out boiler repairs, permission is obtained from Chief Inspector. Major boiler repairs and replacements connected with furnace etc are undertaken in the presence of inspector	2 marks 2 marks
5	f	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 $CaSO_4$) + $Na_2Ze \rightarrow CaZe + 2NaCl$(or Na_2SO_4) MgSO4 (or MgCl2) + $Na_2Ze \rightarrow MgZe + 2NaCl$(or Na_2SO_4) $Ca(HCO3)_2$ (or $Mg(HCO3)_2$ + $Na_2Ze \rightarrow CaZe$ (or MgZe) + 2 $NaHCO_3$	2 marks 2 marks
6	a	**COP(coefficient Of Performance)** of a refrigeration system is the ratio of heat removed from the system to the work supplied to achieve the heat removal COP = Q/W where Q is the heat removed in KJ/ time. W is the work supplied in KJ/ time.	2 marks 2 marks
6	b	**Dry saturated steam:** When there is no liquid present in the vapour at saturation temperature, it is called dry saturated steam. Enthalpy of dry saturated steam(H_s) = Enthalpy of saturated water (h)+ enthalpy of evaporation(L) **Wet steam:** It is a mixture of vapour and liquid at boiling point ie at saturation temperature. Enthalpy of wet steam(H_w) = Enthalpy of saturated water (h)+ enthalpy of evaporation(L)* dryness fraction of steam.	1 mark 1 mark 1 mark 1 mark
6	c	Effect of hard water in domestic purpose: 1. **In washing** Use of hard water in washing results in the wastage of soap, the sticky precipitate adhere on the cloth giving spots and streaks which become more visible on ironing , presence of iron salt causes staining of cloth. 2. **In bathing** since hard water does not lather with soap , the cleaning quality of soap is depressed and it is wasted. 3. **Cooking** boiling point of water is elevated hence more fuel and time are required for cooking. When hard water is used for cooking , bicarbonates of Ca and Mg are deposited as carbonates on the inner wall of the utensils and this requires our heating , which reduces their life. 4. **Drinking** : Possibility of calcium oxalate crystals in the digestive tract is increased. In favourable conditions , they get accumulated either in the kidney or bladder leading to the formation of stones.	1 mark for each point
d		Hard water is passed first through cation exchanger bed which removes all cations like Mg^{2+},Ca^{2+} etc from it and equivalent of H^+ ions are released from	4 marks

	this column to water. After cation exchanger column , the hard water is passed through anion exchange column , which removes all the anions like SO_2^{2-} , Cl^- etc present in the water and equivalent amount of OH^- ions are released from the column to water.H^+ and OH^- ions released from cation exchange and anion exchange columns respectively gets combined to produced water. In this way water coming out from ion exchange column becomes free from cations as well as from anions.	
e	Heat required to converted 5 gram of ice at 0^0 C to water at 0^0 C = 5*80=400 cal. Heat required to converted 5 gram of water at 0^0 C to water at 100^0 C = 5*1*100=500 cal. Heat required to converted 5 gram of water at 100^0 C to steam at 100^0 C = 5*540=2700 cal. Heat required to converted 5 gram of steam at10 0^0 C to steam at 115^0 C = 5*1*15=75 cal. Total Heat = 400+500+2700+75 = 3675cal. **Since the value of Cp of steam is not given due consideration should be given**	1 mark 1 mark 1 mark 1 mark