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	Sub Q. N.	Answer	Marking Scheme
Q 1	(a)	**Attempt any FOUR of the following:**	4*4=16
		1) COP: Coefficient of Performance of refrigerator is the ratio of heat removed from sink (Refrigerating effect) by the device and work done required. COP = Refrigerating effect / Work done The value of COP is always greater than 1.	2M
		2) Energy efficiency ratio (EER): Energy Efficiency Ratio, or EER, is a way to exhibit how well an air-conditioner is operating based on the power being used. EER = Capacity / Power	2M
	(b)	**Classification of Refrigerant:** **i) Primary Refrigerant** **ii) Secondary Refrigerant**	
		Primary Refrigerant: i. The refrigerants which directly take part in refrigeration system are called primary refrigerant. ii. Primary refrigerants are used in domestic refrigerator and Air conditioning system etc. iii. Primary refrigerants are R-134a,R-12,R-21,R-143a etc.	2M

(c)

Secondary Refrigerant: **2M**

i. The refrigerants which are first cooled by primary refrigerant and then used for cooling purpose are called as secondary refrigerant.

ii. It is used in ice plant and in big installation.

iii. Secondary refrigerants are water, brine, glycol etc.

Differentiate between 'air cooled' and 'water cooled' condenser.

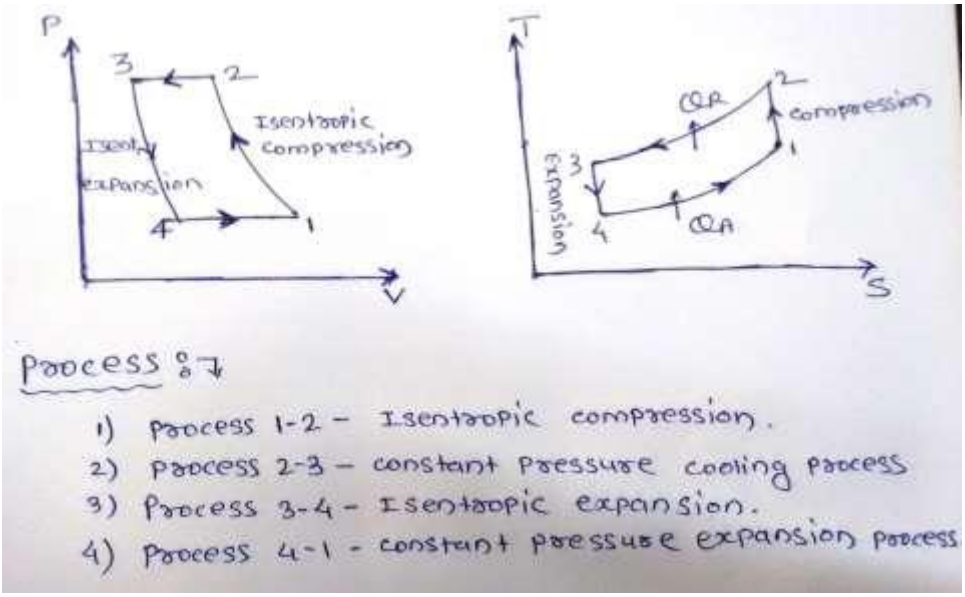
Ans-

Sr. no.	Air cooled condenser	Water cooled condenser
1	Air is used as cooling media.	Water is used as cooling media.
2	Simple construction.	Complicated construction.
3	Low cost.	High cost
4	Low maintenance cost.	High maintenance cost.
5	No piping required to carry air.	Piping required to carry water.
6	No corrosion, no fouling effect	Corrosion and fouling effect
7	Low heat transfer capacity.	High heat transfer.
8	Shorter compressor life.	Longer compressor life.

Any 4 ``point

1M each

d



4M

(e)

Fig. Bell Coleman cycle

Properties of Insulating Material :

i. **Thermal conductivity:** Thermal conductivity of insulating material should be as possible to reduce the thickness of material.

ii. **Non flammable:** Insulating material should be fire proof and nonflammable for safety purpose.

iii. **Odour less:** Insulating material should not posses its own odour and it should not pick the odour of other substance placed in refrigerated space.

iv. **Low Cost:** It should be of low cost and should available easily.

v. **Strength**

vi. **Chemical Stability.**

vii. **Moisture Resistance.**

Any four points

1m each

(f)

i) Photographic industry

ii) Textile industry

iii) Printing industry

iv) Machine tool industry

1m each

(g)

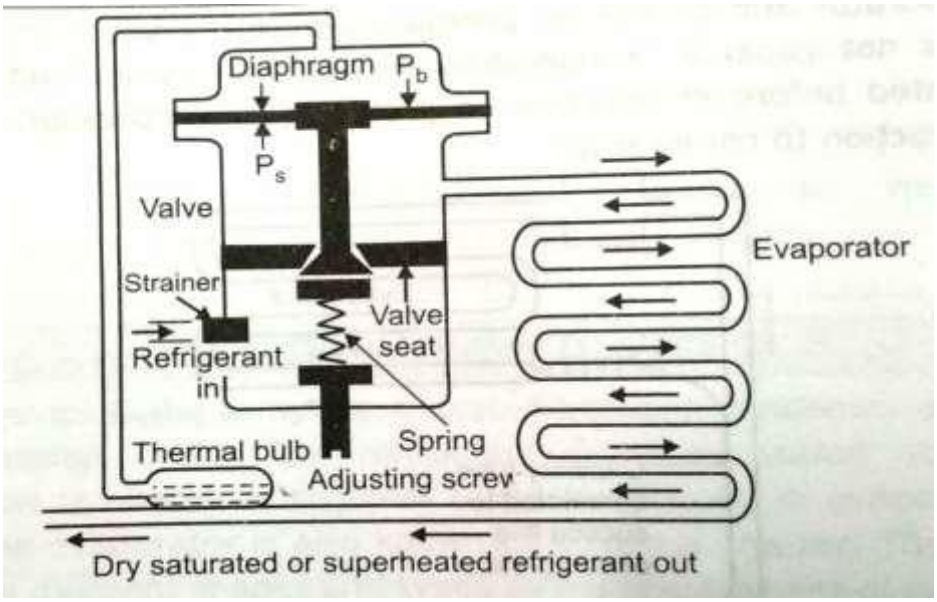
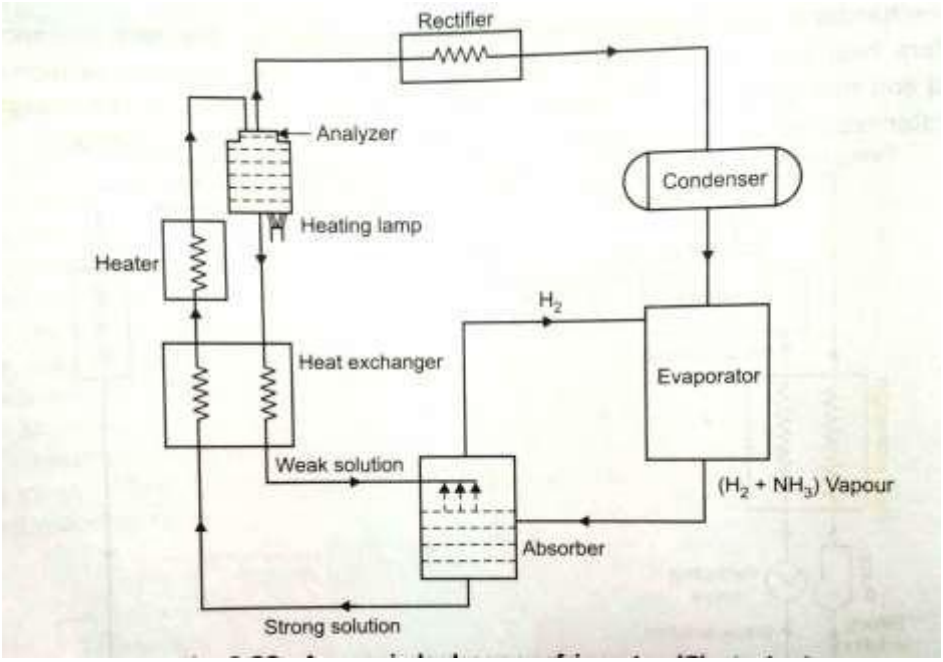


Fig. Thermostatic Expansion valve

4M

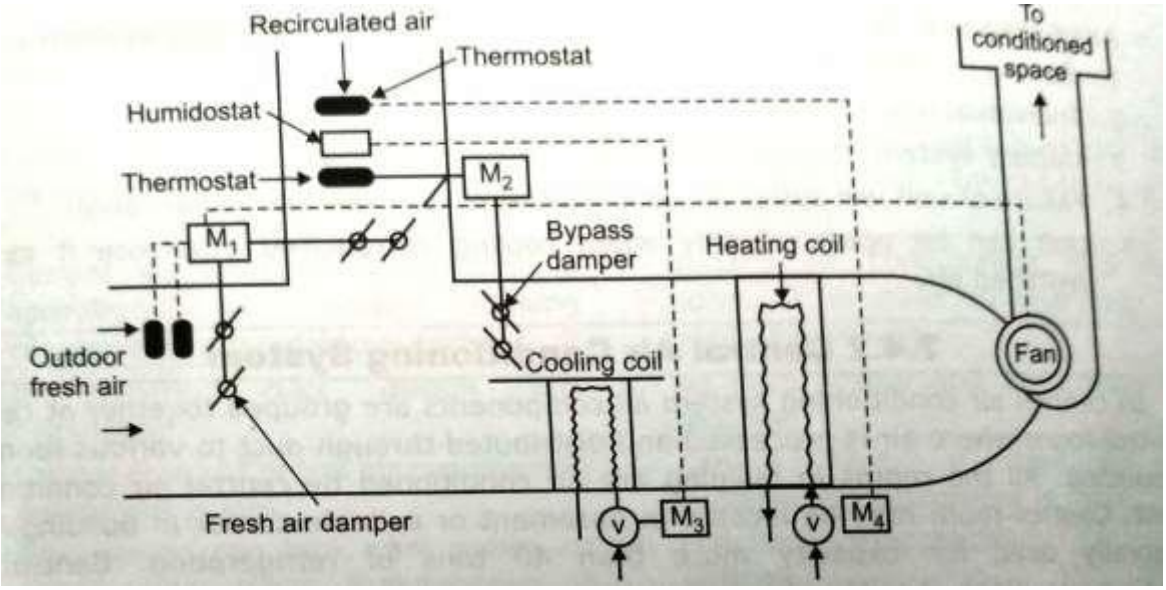
Q. 2	**(a)**	**Attempt any TWO of the following:** **Electrolux Refrigeration system:**	**2*8 =16**



4M

1. It is old system known as three fluid absorption system in which refrigerant is ammonia and solution used is aqua ammonia. Third liquid is hydrogen gas.
2. Circulation of system is achieved by providing high pressure in condenser and generator and low pressure in evaporator and absorber.
3. Liquid ammonia flows under gravity into evaporator. As soon as ammonia liquid enters evaporator partial pressure of ammonia decreases due to presence of hydrogen.
4. Mixture of ammonia vapour and hydrogen vapour passed to the absorber. Weak solution of aqua ammonia is sprayed into absorber where it absorbs ammonia vapour and converted into strong solution. Hydrogen left is recirculated in evaporator. Then strong solution passed through heat exchanger where heat is transfer from weak aqua ammonia to strong aqua ammonia solution. **4M**
5. Strong aqua ammonia solution heated in generator and due to addition of heat ammonia vapour are release and strong solution converted into weak solution, which is passed to the absorber.
6. Then moisture in ammonia removed by analyzer and rectifier.
7. Advantage of this system is it has no moving parts, no noise and can be used where no electricity is available.

	(b)	**Year Round air conditioning system:**	

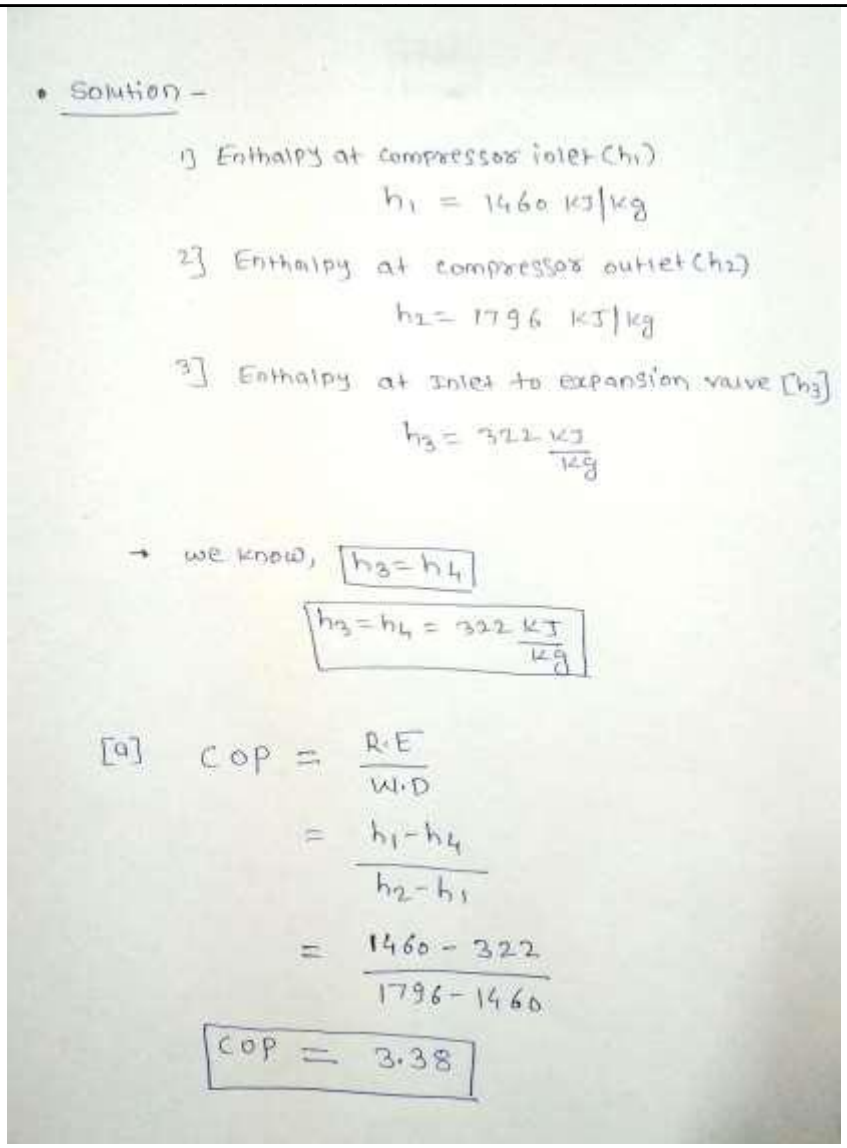
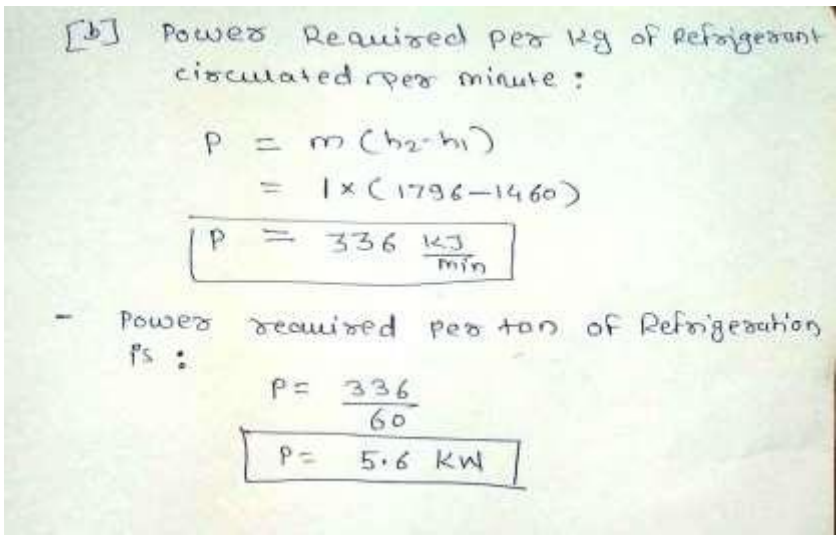


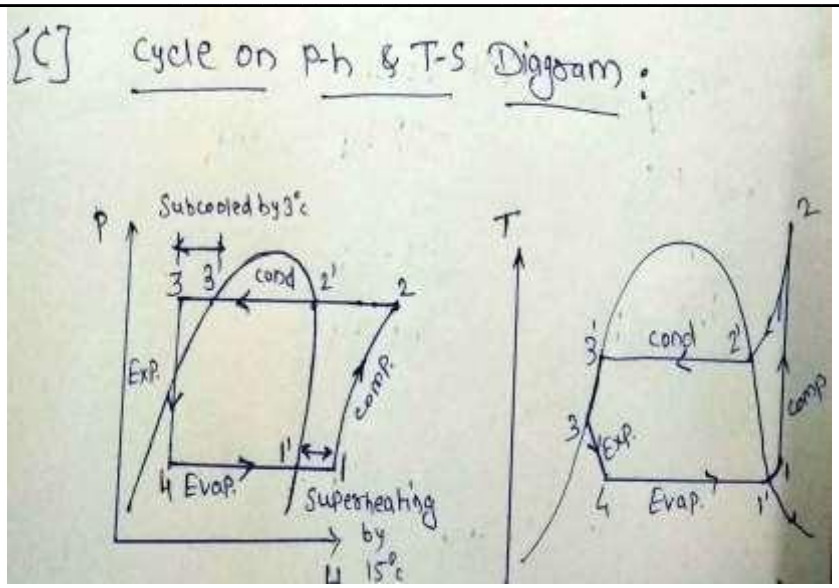
4M

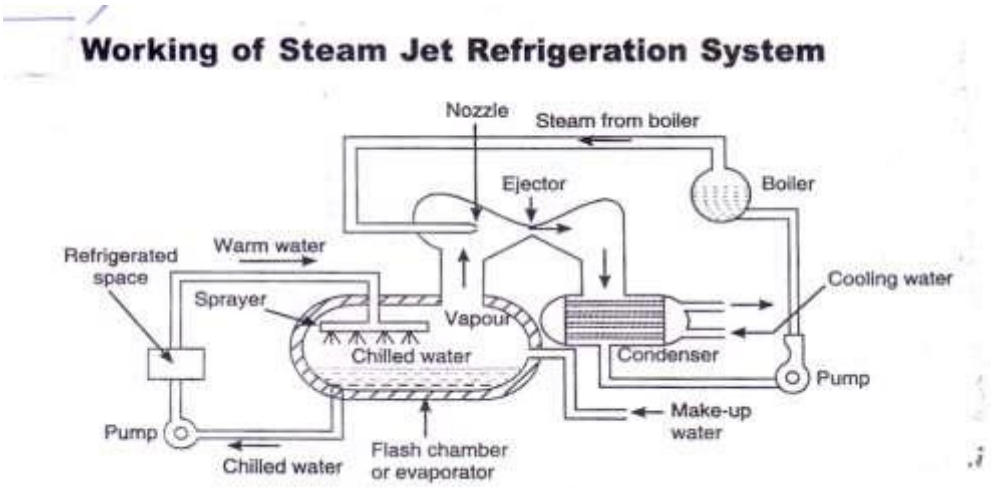
Fig. Year Round AC

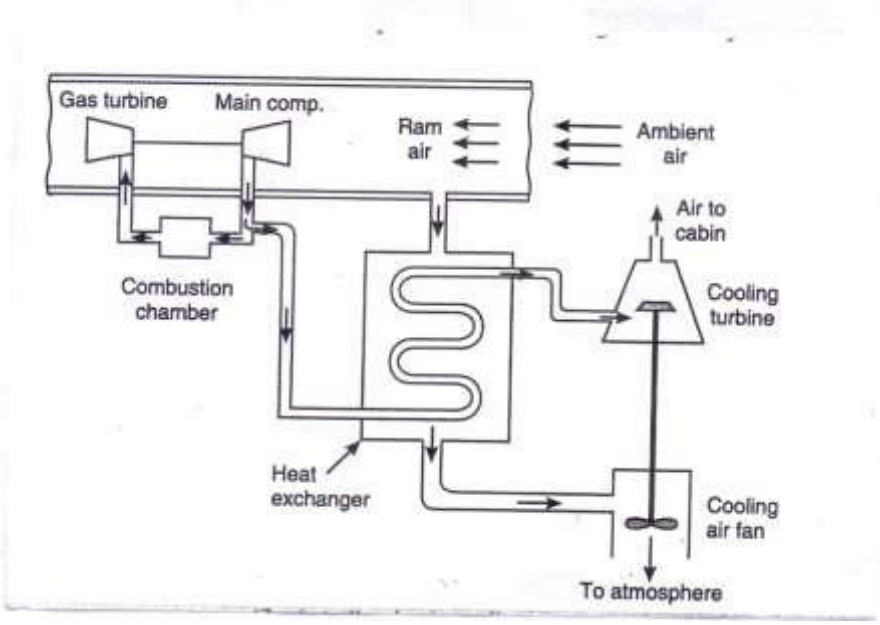
1. Summer air conditioner gives comfort condition in summer season. Winter air conditioner gives comfort condition in winter season.
2. Summer air conditioner cannot be used in winter and winter air conditioner cannot be used in summer.
3. Therefore, to provide comfort condition throughout year, year round air conditioner is used which is capable of maintaining specified temperature and humidity.
4. Such system more useful as it reduces the capital cost.
5. The amount of outdoor fresh air is controlled by motor. The air conditioner is designed such that when outdoor air temperature is either above or below a certain selected value, it assume the season as summer or winter.
6. In summer season, bypass damper is almost closed and most air is passed through cooling coil. Then it passed through heating coil. In winter season, bypass damper is in almost open position and most of air is directly passed to the heating coil by passing cooling coil.

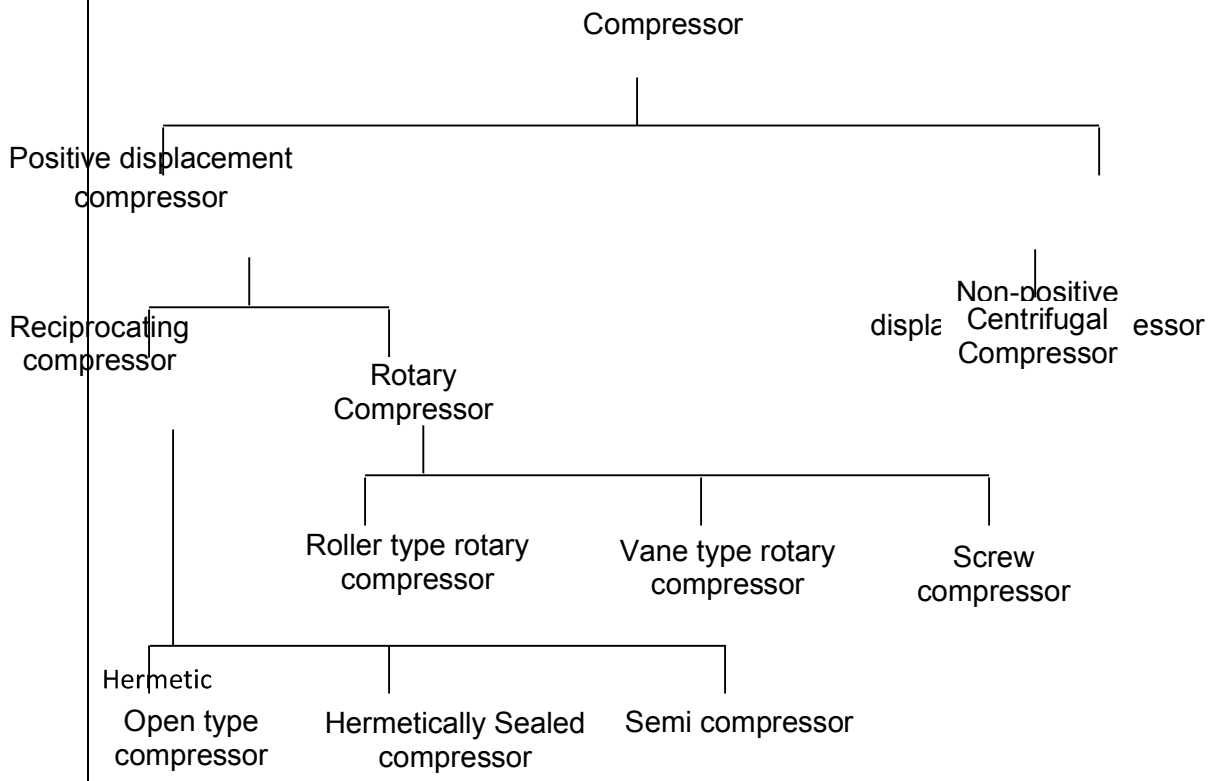
4M

	(c)		**3M**
			**3M**

		[C] Cycle on P-h & T-S Diagram: 	**2M**

Q. No .3	**a)**	**Working of Steam Jet Refrigeration System**  Steam jet refrigeration system. Boiling point of water changes as per the pressure. Water boils at 100^0c at 1 atm pressure. This boiling temperature of water can be decreased by reducing pressure on it. If the pressure on water surface is reduced to 5 cm of water column the temperature of evaporation can be reduced to 6^0c. This principle of boiling water at 1000 temperature is adopted in steam jet refrigeration. The main components of the steam jet refrigeration system, as shown in above fig. are the flash chamber or evaporator, steam nozzles, ejector and condenser.	02+02

		The flash chamber or evaporator is a large vessel and is heavily insulated to avoid the rise in temperature of water due to high ambient temperature. It is fitted with perforated pipes for spraying water. The warm water coming out of the refrigerated space is sprayed into the flash water chamber where some of which is converted into vapours after absorbing the latent heat, there by cooling the rest of water. The high pressure steam from the boiler is passed through the steam nozzles there by increasing its velocity. This high velocity steam in the ejector would entrain the water vapours from the flash chamber which would result in further formation of vapours. The mixture of steam and water vapour passes through the venturi-tube of the ejector and gets compressed. The temperature and pressure of the mixture rises considerably and fed to the water cooled condenser where it gets condensed. The condensate is again fed to the boiler as feed water. A constant water level is maintained in the flash chamber and any loss of water due to evaporation is made up from the make-up water line.	
Q. No .3	**b)**	**Simple Air Craft Cooling System.** 	04

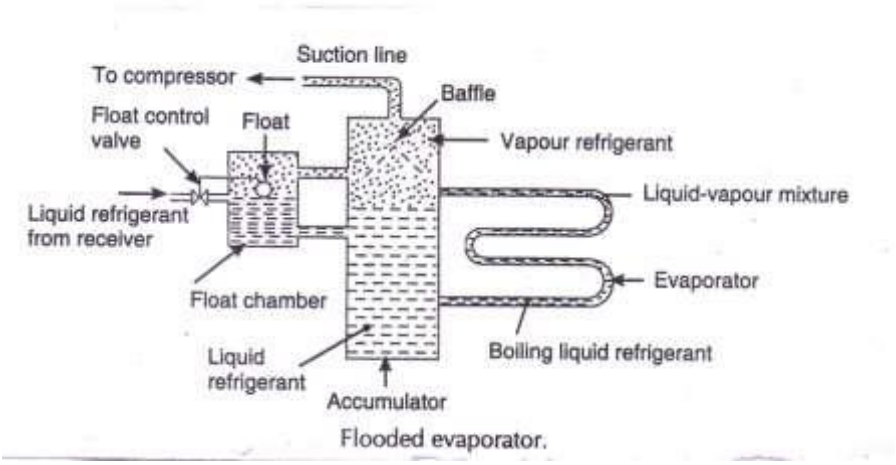
Q. No .3	**c)**	**Classification of Compressor** 	04
Q. No .3	**d)**	Air conditioning is that branch of engineering science which deals with study of conditioning of air. **Air-conditioning :-** Air-conditioning is the simultaneous control of temperature, humidity, motion and purity of air within an enclosed space, that are either conducive to human comfort or are required by a product or process. **Purpose of Air-conditioning –** Air-conditioning is widely used in industry, commercial places, offices, hospitals and for human comfort. **Industry Air-conditioning –** Used to control the condition of atmosphere required to carry out industrial process most efficiency, economically with better quality. Ex-Textile mills, paper mills, printing and photo processing plants etc. **Comfort Air-conditioning –** It is provided for ultimate comfort of human being Ex-air-conditioning system at home, office etc. In this case stay time of occupant is prolong.	04

		Commercial Air-conditioning – It is similar to comfort air-conditioning except that stay time of occupant is short. Ex-air-conditioning system is bank, departmental store etc.	
Q. No .3	**e)**	**Factors affecting on human comfort** Following factors are affecting on human comfort. 1. **Temperature of air –** In air conditioning, the control of temperature means the maintenance of any desired temperature within an enclosed space even though the temperature of the outside air is above or below the desired room temperature. This is accomplished either by the addition or removal of heat from the enclosed space as and when demanded. It may be noted that a human being feels comfortable when the air is at 21^0C with 56% relative humidity. 2. **Humidity of air –** The control of humidity of air means the decreasing of increasing of moisture contents of air during summer or winter respectively in order to produce comfortable and healthy conditions. The control of humidity is not only necessary for human comfort but it also increases the efficiency of the workers. In general, for summer air conditioning the relative humidity should not be less than 60% whereas for winter air conditioning it should not be more than 40%. 3. **Purity of air –** It is an important factor for the comfort of a human body. It has been noticed that people do not feel comfortable when breathing contaminated air, even if it is within acceptable temperature and humidity ranges. It is thus obvious that proper filtration, cleaning and purification of air is essential to keep it free from dust and other impurities. 4. **Motion of air –** The motion or circulation of air is another important factor which should be controlled, in order to keep constant temperature throughout the conditioned space. It is therefore, necessary that there should be equi-distribution of air throughout the space to be air conditioned.	04

Q. No.			
Q. No .3	**f)**		04 any four points

Central air conditioning system	Unitary air conditioning system
1. Ton capacity is more than 25 tons of refrigeration.	1. Ton capacity is less than 25 tons of refrigeration.
2. Mass flow rate of air handled is around 2000 m^3/min.	2. Mass flow rate of air handled is less.
3. All the rooms are required to be maintained at more or less similar condition.	3. Each room can be maintained at different conditions.
4. Central air conditioning is located in basement or outside the building.	4. Unitary air conditioning is located in every room which required to be air conditioned.
5. Central air conditioning is quiet in operation as noise making components are located outside.	5. Unitary air conditioning may be noisy. It is quiet in operation if used as split unit.
6. It requires duct design and installation.	6. No duct design and installation is required.
7. Capital cost of Central air conditioning equipment is less.	7. Capital cost of unitary air conditioning equipment is more.
8. One person can look after entire air conditioning plant maintenance is convenient and easy.	8. Maintenance is difficult.
9. If air conditioning in a particular room is not required. It can not be switched off.	9. If not required, it can be switched off.
10. If there is failure or fault in air conditioning plant, all rooms air conditioning is affected.	10. If there is failure, any air conditioning of that room is affected.

Q.No.4	**a)**	**Flooded Type Evaporator**	02



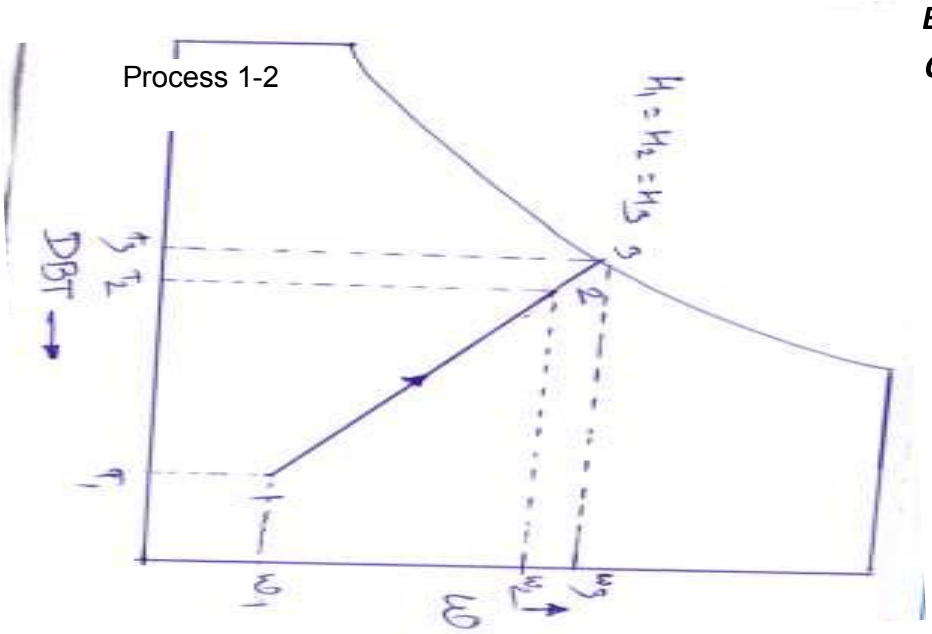
Flooded evaporator.

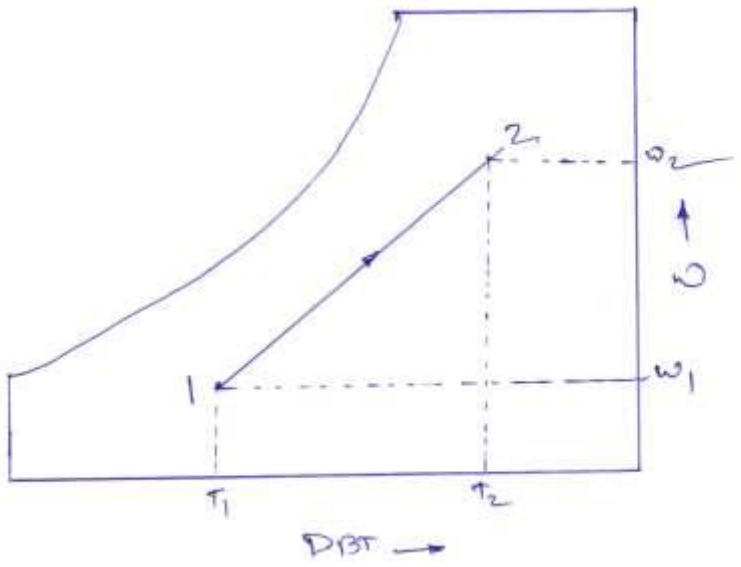
02

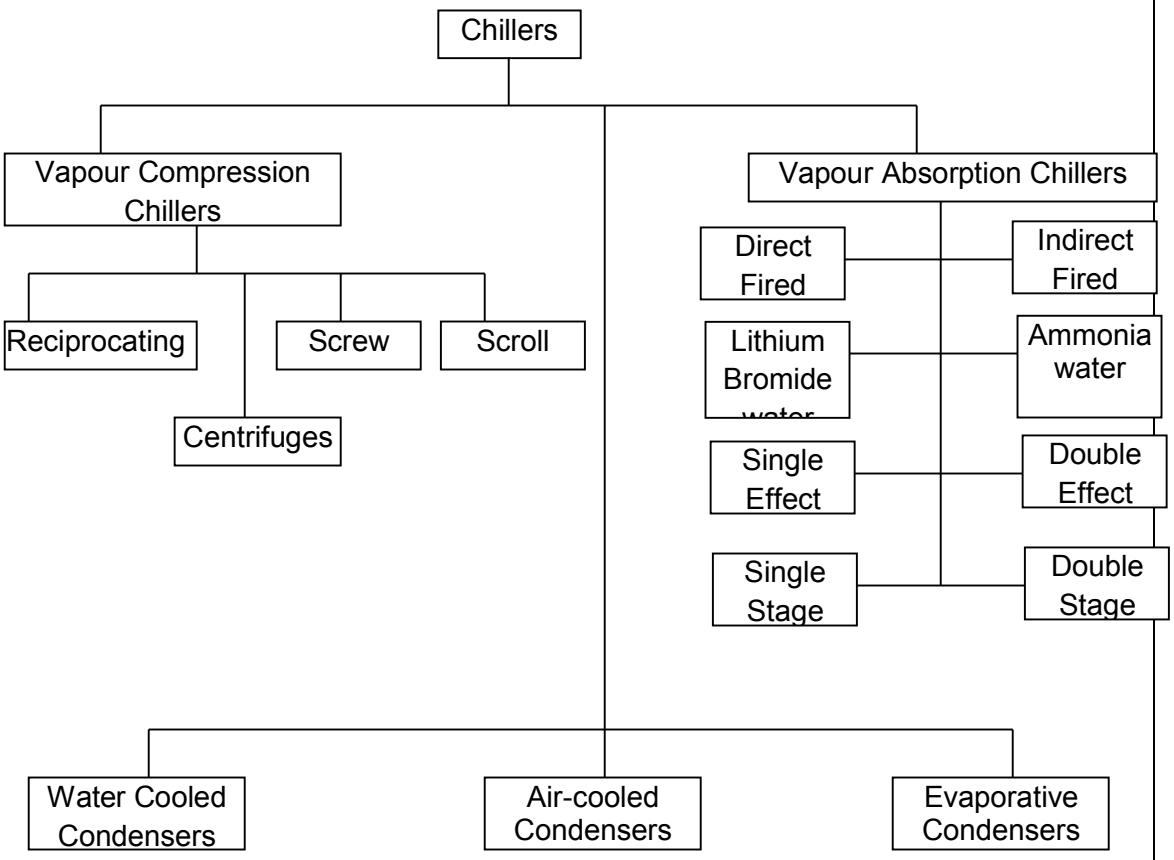
In a flooded evaporator, as shown in above fig. a constant liquid refrigerant level is always maintained. A float control valve is used as an expansion device which maintains constant liquid level in the evaporator. The liquid refrigerant from the receiver passes through a low side float control valve and accumulator before entering the evaporator coil. The accumulator (also called surge drum or surge tank) serves as a storage tank for the liquid refrigerant from the vapour returning to the compressor. Due to the heat supplied by the substance by the substance to be cooled, the liquid refrigerant in the evaporator coil vaporizes and thus the liquid level falls down. The accumulator supplies more liquid to the evaporator in order to keep the liquid refrigerant in the evaporator at proper level in this way, the level of liquid refrigerant in the accumulator also falls down. Since the float with the float chamber rests on liquid refrigerant at the same level as that in the accumulator, therefore the float also falls down and open the float valve. Now the liquid refrigerant from the receiver is admitted into the accumulator. As the liquid level in the accumulator rises and reaches to the constant level the float also rises with it unit the float control valve closes.

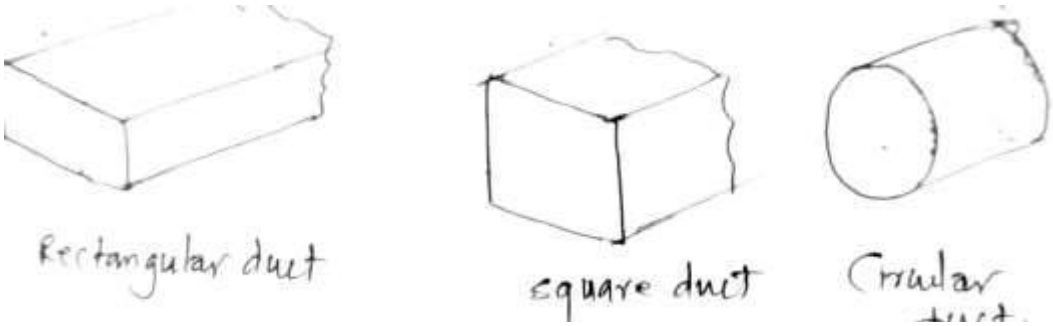
Since the evaporator is almost completely filled with liquid refrigerant, therefore the vapour refrigerant from the evaporator is not superheated but it is in a saturated condition. In order to prevent liquid refrigerant to enter into the compressor, an accumulator is generally used with the flooded evaporatros. The liquid refrigerator trapped in the accumulator is re-circulated through the evaporator. The evaporator coil is connected to the accumulator and the liquid flow from the accumulator to the evaporator coil is generally by gravity. The vapour formed by vaporizing the liquid in the colil being lighter, rises up and passes on to the top of the accumulator from where it is supplied to the suction side of the compressor. The baffle plate arrests any liquid present in the vapour. The advantages of the flooded evaporator is that the whole surface of the evaporator coil is in contact with the liquid refrigerant under all the load conditions. Thus it gives high heat transfer rates. The flooded evaporators are especially used in the chemical and food processing industries.

Q.No.4	**b)**	**Green House Effect:-** It is earths ability to retain heat. When the sun's rays reach the planet, approximately two thirds of the thermal energy enters earth's atmosphere and is absorbed by the planet's surface. The earth then emits this thermal energy, which is absorbed by the atmosphere. The atmosphere radiates the heat back towards the earth planet warm and controls the earth's climate. Greenhouse gasses such as water vapour, carton dioxide and clouds as well as small particles lemons as aerosols, trap same heat in lower part of earth's atmosphere. This is known as green house effect. In fact without this effect, life on earth would not be possible because the planet would be too cold. **Global Warming:-** Global warming is an increase in earth's overall temperature. It has been changing at a much faster rate than normal due to accelerated generation of green house gasses due to industrialization. It is a threat to human being, general upward trend of the earth's temperature will drastically change accessibility to food, water, row material and energy sources for animals and humans alive. Global warning has increased ocean level, leakage of CFC also help in depletion of ozone layer, which causes to allow the infrared radiation directly on earth. The trapping of this infrared radiation causes the earth's surface and lower atmospheric layer to warm to the higher temperature.	02 02
Q.No.4	**c)**	i) DBT – Dry bulb temperature of air is the temperature recorded by ordinary thermometer and it is not affected by the moisture present in the air. ii) DPT – It is the temperature of air recorded by thermometer when the moisture present in its begins to condense. iii) Relation humidity – It is the ratio of actual mass of water vapour in a given volume of moist air to the mass of water vapour in the same volume of saturated air at the same temperature and pressure. iv) Dew Point Depression – It is the difference between the dry bulb temperature and dew point temperature of air.	One each
Q.No.4	**d)**	**Industrial Application of Air-conditioning System –** Following are the major application of air-conditioning system used in industries. i) Photographic Industry – Provides accurate control of temperature, humidity for manufacturing as well as processing in photographic films. ii) Textile Industry – Relative humidity and temperature are the key factors of textile industry. Humidity has effect on strength, quality of fabric to make them soft and reliable instead of brittle and weak. iii) Printing Industry – Specific temperature and humidity is maintained in printing industry. Paper become too dry in low humidity and improper stamping takes place. Paper swell in high humidity and ink spreads as well as taken time to dry causing non uniform printing. iv) Machine tools Industry – Same machining processes requires accurate temperature and humidity. Ex. Processing in manufacturing of bearing, scientific instruments, electronic devices test gauges and precision gears etc. where close tolerance of dimensions is required.	Any four 04

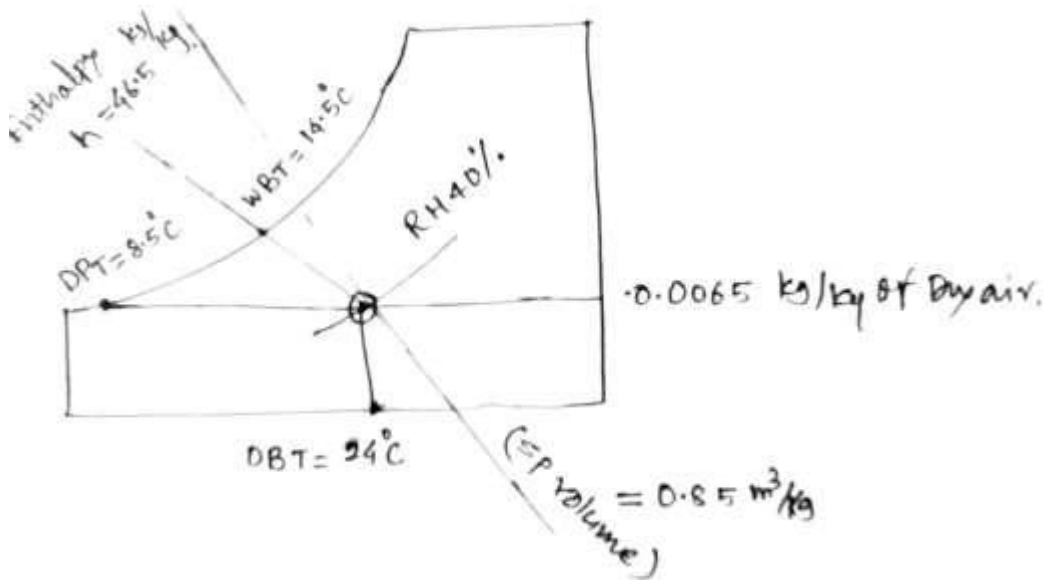
Q.No.4	e)	***Evaporative Cooling on***  ***Psychometric Chart***	02

		Heating and Humidification Process Process 1-2 Heating with humidification  	02

Q.No.4	**f)**	***Classification of Chillers*** 	
5		**Attempt any Two**	8x2=16
	(a)	**Classify the different types of Ducts and explain any one with neat sketch.** **Solution.** **Ducts** are classified according to their use as : (air distribution system mainly consists of supply ducts and return ducts) **1.According to cross section:** a. Circular Duct b. Rectangular Duct c. Square Duct **2.According to pressure:** a. Low pressure duct-when static pressure in duct is less than 50 mm of water	(04 marks for calssify)

		gauge. b. High pressure duct- when static pressure in duct is 150 to 250mm of water gauge. c. Medium pressure duct-when static pressure in duct is 150mm of water gauge. **3.According to velocity:** a. Low velocity duct: when velocity in duct upto 600m/min. b.High velocity duct: when velocity in duct more than 600m/min.  Rectangular duct/Circular /Square ducts- **(Any one)** -Generally made up of galvanised iron sheet metal or aluminium sheet metal.Now a days non- metallic ducts materials used for manufacturing if ducts such as –glass fiber, cement asbestos. -most commonly used shape is the rectangular duct; as it provide flat surface and easier to work with room surface. -Practical point of view square duct preferred, appearance point of view square ducts are used due to their symmetry. - Circular ducts are economical; as it can carry higher amount of air in less space as compared to other ducts. Required less duct material means less surface results in less friction.	(02 marks for sketch) (02 marks for Explanation)
	b)	**What are the different types of heat loads to be taken into account to calculate the heat load of Auditorium of your institute?** **Ans:** **List of Heat sources in Auditorium-(Here assume a large Auditorium for air**	

		conditioning)- Two main components of heat load are-1.Sensible heat load and 2.Latent heat load. **1.Sensible heat gain through structure by conduction-** $Q=U^* A^*(t_o-t_i)$ Where-Q=Total heat transfer, A=Outside area of wall, t_o= Outside air temperature, t_i= Inside air temperature, **2.Sensible heat gain from solar radiation through walls and roof-** $Q=U*A*t_e$ Where Q=Total heat transfer, A=area of roof or wall, t_e=Equivalent temperature differential. **3.Heat gain due to infiltration** –(using air change method) Amount of infiltrated air through windows and wall is $= (L*W*H*A_c)/60$ m^3/min. Both sensible and latent heat load gain. **4.Heat gain through ventilation-** The ventilation (supply of outside air) is provided to the conditioned space in order to minimise carbon dioxide and other undesirable gases. ½ air should be change per hour in buildings in normal ceiling heights. The outside air adds sensible as well as latent heat load. **5. Heat gain from appliances/Lighting Equipment's-** Appliances used may be Projector, lights etc. Heat gain can be calculated as- Q=(Total Wattage *use factor*Allowance Factor). **6.Heat gain from Occupants-** The human body in cooled space constitutes cooling load of sensible(45.4 K cal/hr) and latent heat(37.5K cal/Hr). Heat gain depends on average number of people present in Auditorium. Q=(no of persons)*(load per person).	1 mark 01mark 01 mark 01 marks 02 mark 02marks

	(c)	**With the help of psychromertic chart, find the properties of air at 24^{0}C DBT and 40% RH.** **(i) DPT (ii) WBT (iii) Specific volume of air (iv) Enthalpy of air** **Draw simple psychromertic chart showing all above properties-** **Note-tolerance of (+/- 3 to 4) for psychrometric properties.**  **Enthalpy=46.5 KJ/Kg,** **DPT=8.5 ^{0} C** **WBT=14.5^0 C** **Specific volume=0.85 m^3/kg** **Specific humidity=0.0065kg/kg of dry air.**	(1 Mark for each properties and 03 marks for sketch)
Q	**6**	**Attempt any Four**	4*4=16
	(a)	**State the methods of improving COP of VCRS system and Draw it on p-h & T-S charts.** COP can be improved by following methods- a. By introducing flash chamber b. By using pre-cooler or Accumulator c. By sub-cooling the liquid refrigerant by the vapour refrigerant. d. sub-cooling by liquid refrigerant.	04

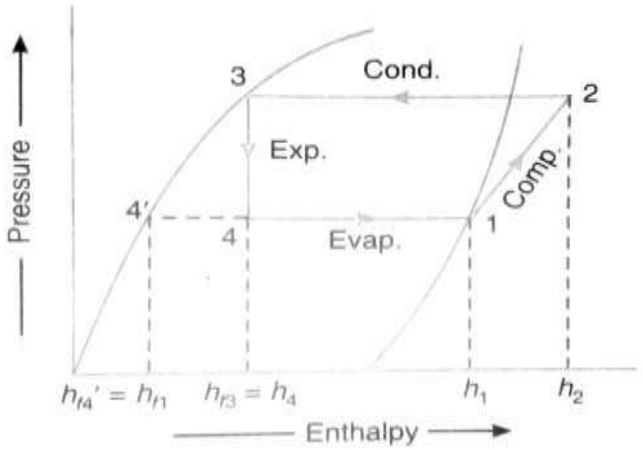


Fig: a- By introducing flash chamber.

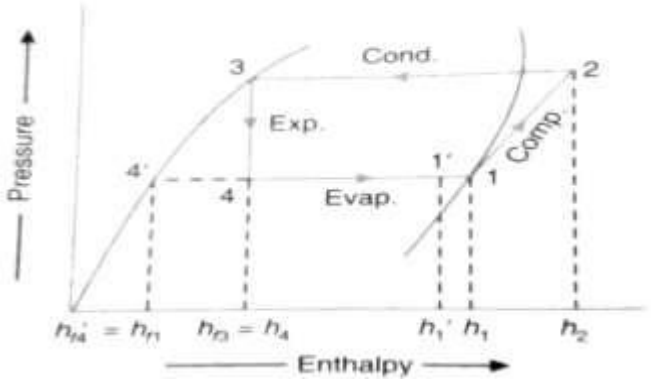


Fig:b By using pre-cooler or Accumulator .

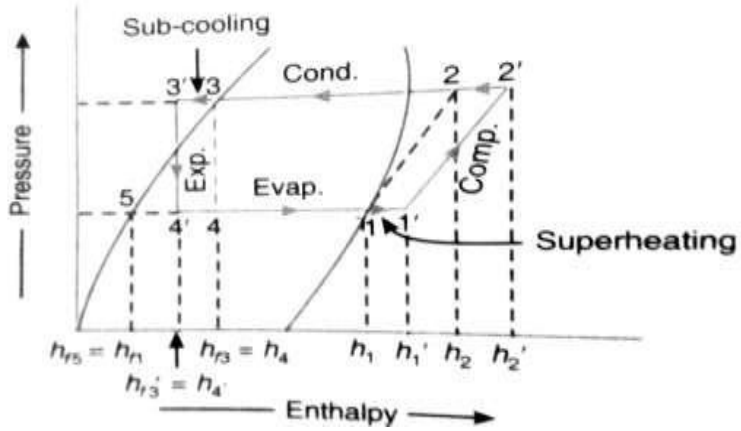


Fig :c By sub-cooling the liquid refrigerant by the vapour refrigerant.

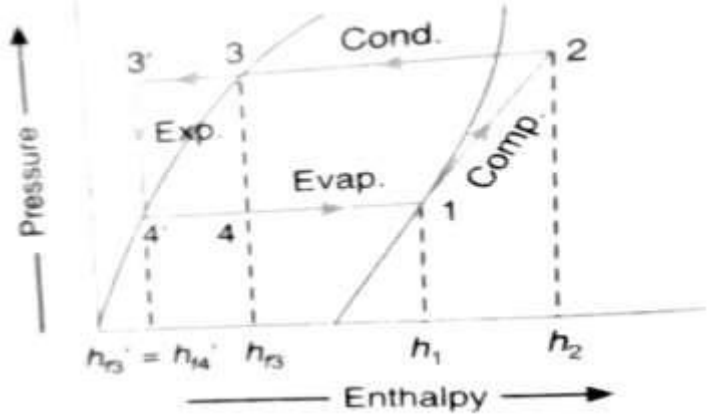


Fig : d Sub-cooling by liquid refrigerant.

Diagram- 4 marks

b) **Explain any one type of humidifier.**

Solution -To increase moisture content or relative humidity; humidifier used.

Humidification may be obtained by following methods-

-by injecting steam

-by atomizing the water.

-by evaporating the water.

-simply by air washing.

(Any one of the following types with neat fig and explanation.)

(Figure 02 Marks and Explanation 02 marks)

1.Atomization type of humidifier:

- Compressed air used for atomization.

-when compressed air passed through the narrow section at high velocity result lifting water from reservoir.

-compressed air atomized water which result to increase humidity.

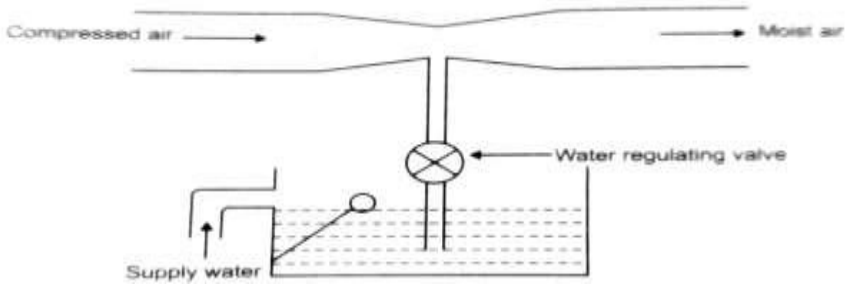


Fig: Atomization of water.

OR

2.Revolving wick type humidifier:

-When drum rotates; the wetted wick comes in contact with air and humidifies it.

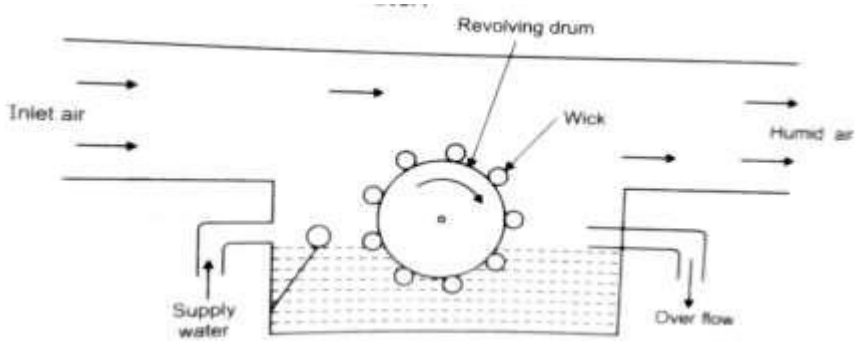


Fig: Revolving wick type humidifier.

OR

3.Humidification by Evaporation of water:

-Generated stem due to heating coil; mix with incoming air and humidification of air takes place.

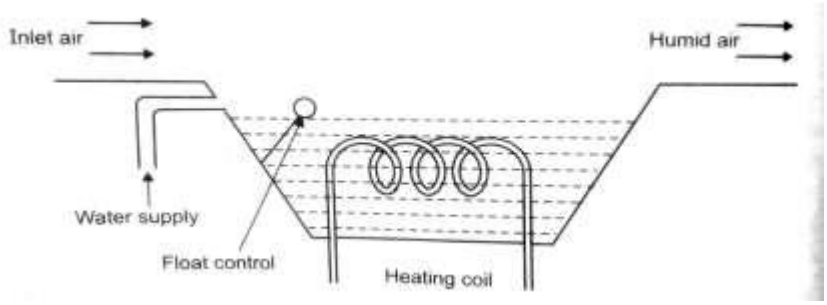


Fig: Evaporation of water.

OR

4. Humidification by air washing:

-with the help of spray chamber humidification of air takes place.

-water at high pressure is sprayed through spray nozzle.

- Air washer decreases the temperature of air .To compensate this heating coil placed at inlet. Most common effective method for humidification.

04

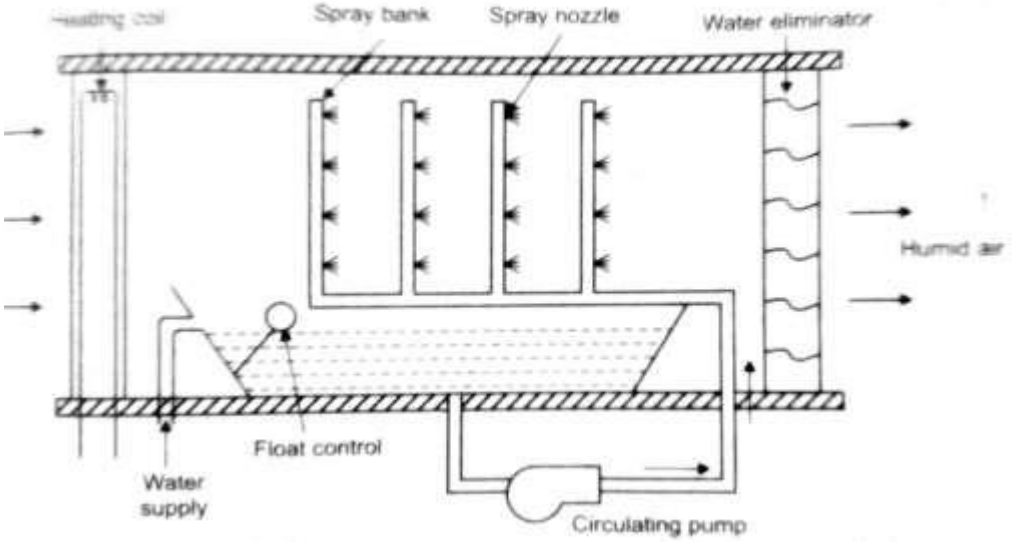


Fig: Humidification by Air washing.

c) **Write the components of Automobile A/C system with their function.** 04

Compressor-Low pressure R134a vapour entering the compressor is compressed to become high pressure/temperature R134a vapour. This is then circulated along with lubricant oil to the condenser.

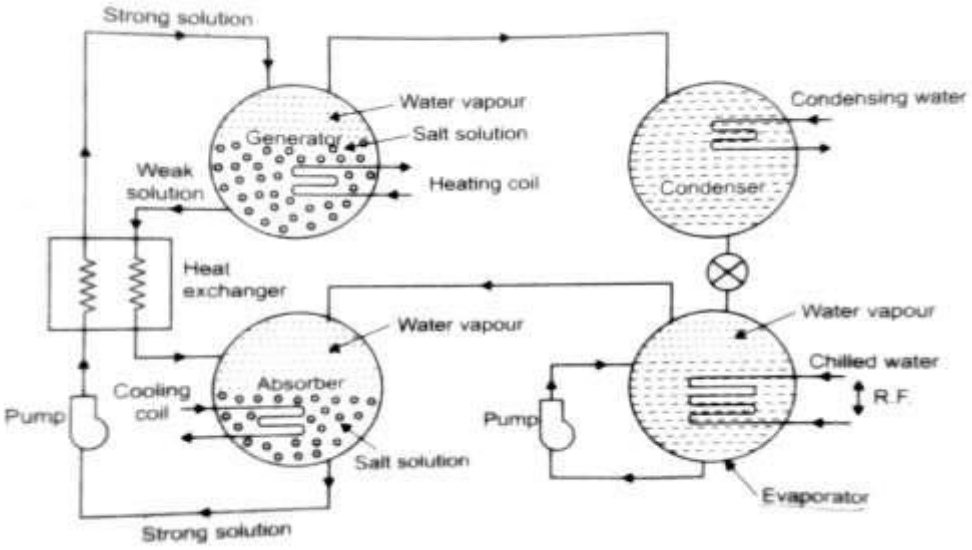
Condenser - As the high pressure/temperature vapour travels through the condenser, heat is released to the cooler ambient air passing over the condenser tubes condensing the vapour into a liquid.

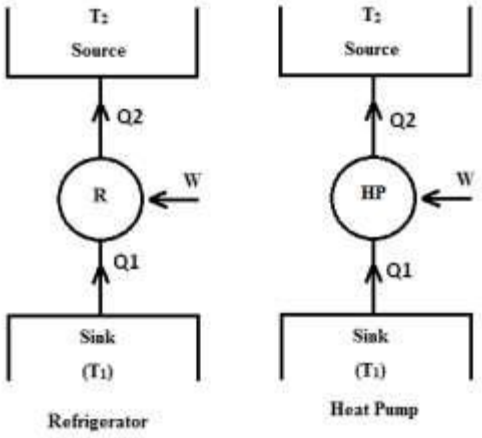
Filter- This high pressure/temperature liquid then travels through the filter drier onto the expansion valve.

Expansion Valve- where a small variable orifice provides a restriction against which compressor pushes.

Suction from the compressor pulls the high pressure/temperature liquid R134a through small variable orifice of the TX valve and into the low-pressure side of the A/C system.

Evaporator- The R134a is now under low pressure/temperature vapour where heat from the cabin being blown over the evaporator coil surface is absorbed into the colder low pressure refrigerant The R134a is then pulled through the evaporator and into the compressor.

06	**(d)**	**Draw with labelled sketch Li-Br absorption system.**  **Fig: Lithium –Bromide absorption system.**	**labelled sketch 04 marks**
	(e)	**Difference between heat pump and Refrigerator:** **Heat Pump-** 1.Heat Pump used to maintain temp of the system above atmospheric temp. 2.Heat added to the system. 3.(COP)HP=(COP)R+1 4.Amount of heat supplied to source is important 5. Application: Room heating in winter. **Refrigerator-**	**(1 mark for each difference)**

		1. Refrigerator used to maintain the temperature of the system lower than atmospheric temperature. 2. (COP)R=(COP)HP-1 3. Heat is extracted or taken out from the system. 4. Amount of heat removed from the sink is important. 5. Application: For confined space cooling.  	
	f.	**State the working principle of Capillary tube. State its two advantages.** **Solution.** -The pressure drop through the capillary tube depends on internal diameter and length of tube. Due to friction between refrigerant and internal surface of the capillary tube pressure drop takes place.Small diameter of the tube reduces condensing pressure to evaporator pressure. The pressure drop depends upon internal diameter of the tube. **Advantages:** 1. The cost of Capillary tube is less than all other expansion devices 2. When the compressor stops, the refrigerant continues to flow into the evaporator and equalizes the pressure between the high side and low side of the system; this decreases the starting load on the compressor. 3. Since the refrigerant charge in a capillary system is critical, therefore no receiver is necessary. 4. Rough handling of appliances does not affect working of expansion device.	**(Working principle 02 marks and 02 marks for two advantages)**