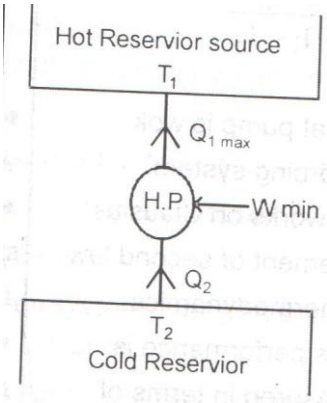
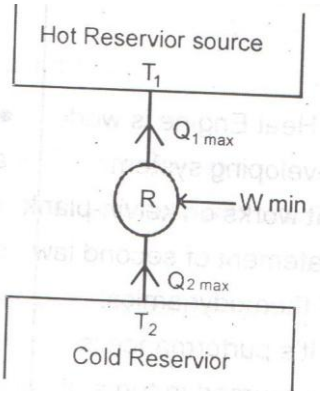
Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in themodel answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may tryto assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given moreImportance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in thefigure. The figures drawn by candidate and model answer may vary. The examiner may give credit for anyequivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constantvalues 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.	Answer	Marking Scheme
1		**Attempt any FIVE of the following:**	(1marks define and 1marks for unit)
	a.	**(a) i) Refrigeration –** It is the process of maintaining the temperature of defined space below the surrounding temperature by continuously removing the heat. **Unit -** ton	**(**2marks)
		ii) Global warming - Global warming is the increase of earth's average surface temperature due to effect of greenhouse gases such as carbon dioxide emission from burning fossil fuel or from deforestation which trap the heat and increases temperature of earth's surface. Refrigeration and air conditioning system also contribute to global warming due to the leakage of refrigerant while servicing the equipment or damage.	
		----------	
	b.	**(b) i) Heat Pump –** It is device which pumps the heat to high temperature body. It is used to heat houses in winter season. **ii) Refrigerator –** It is device which provides cooling in defined region by continuously removing the heat from low temperature body. It is used to cool the houses in summer.	(2marks define and 2marks diagram)
			
		Heat pump	
			
		Refrigerator	

c. **c) Primary Refrigerant:**

i. The refrigerants which directly take part in refrigeration system are called primary refrigerant. 4marks

ii. Primary refrigerants are used in domestic refrigerator and Air conditioning system etc.

iii. Primary refrigerants are R-11,R-12,R-21,R-143a etc.

Secondary Refrigerant:

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.

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d.

i) Air Conditioner – R-22, R-114

ii) Domestic Refrigerator – R-12, R-143a

iii) Ice Plant – In primary circuit Ammonia and secondary circuit Brine solution. (1marks each)

iv) Water cooler – R-12, R-143a

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e.

Given: Temperature of source $\mathbf{T_1}$ **=** 30 + 273 = 303 K

Temperature of sink $\mathbf{T_2}$ **=** -10 + 273 = 263 K (4marks)

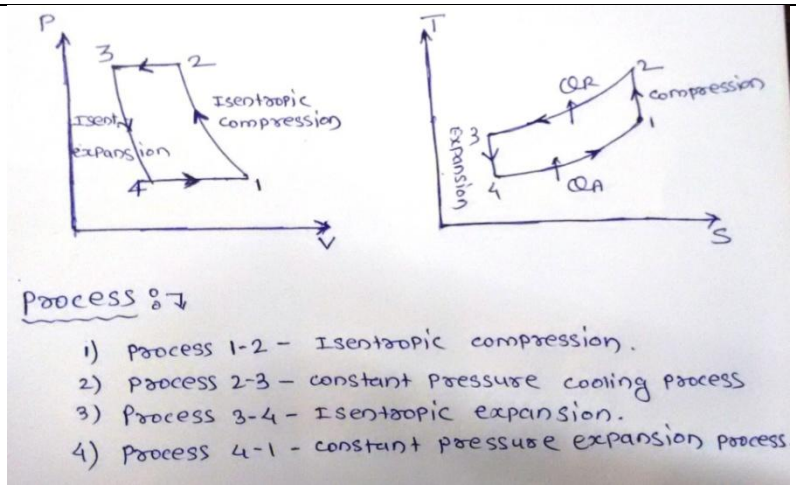
Then, Carnot COP is -

$$(COP)_{Carnot} = \frac{T_2}{T_1 - T_2} = \frac{263}{303 - 263} = 6.575$$

No machine can have COP more than COP of Carnot refrigerator operating between same temperature limits.

Therefore, Inventor claim is not correct as his COP is 7.4, which is more than Carnot COP which is 6.575

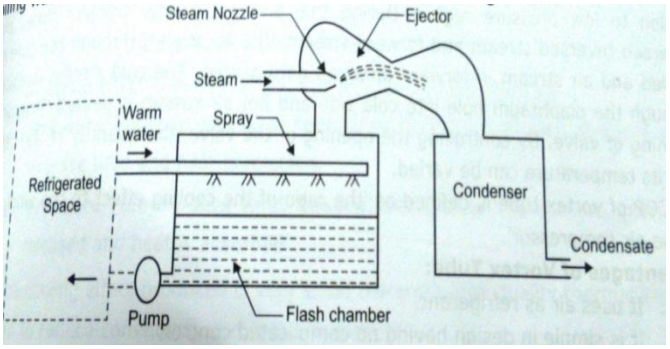
f.



(2M diagram and 2M process)

Bell Coleman cycle

g.



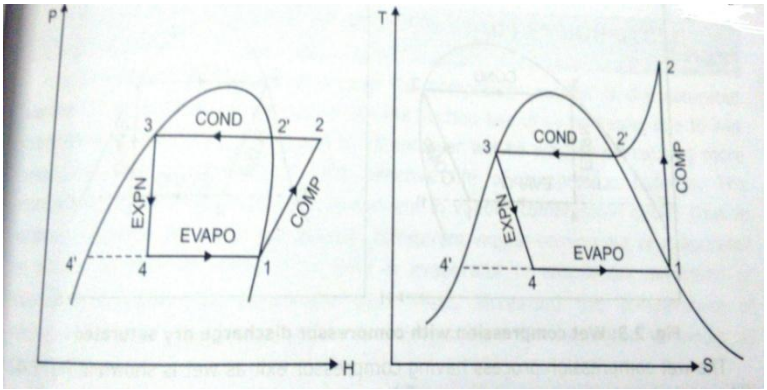
4marks

Steam jet Refrigeration

2

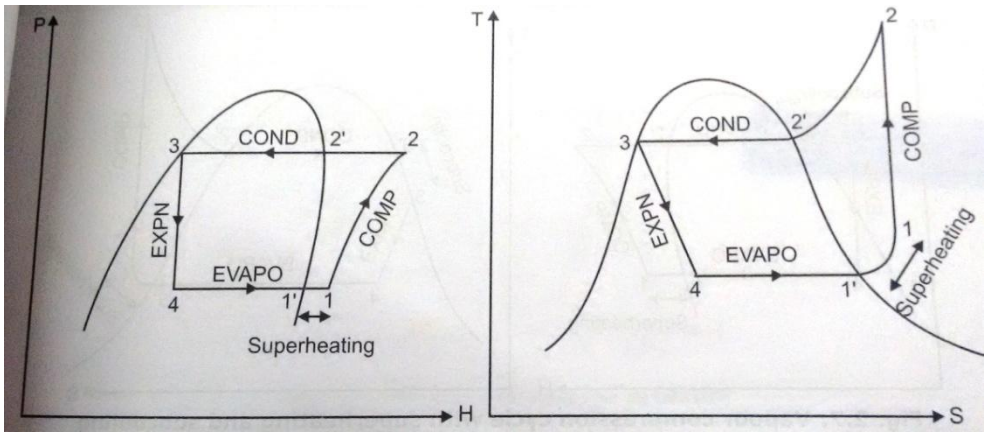
Attemp any FOUR

a.

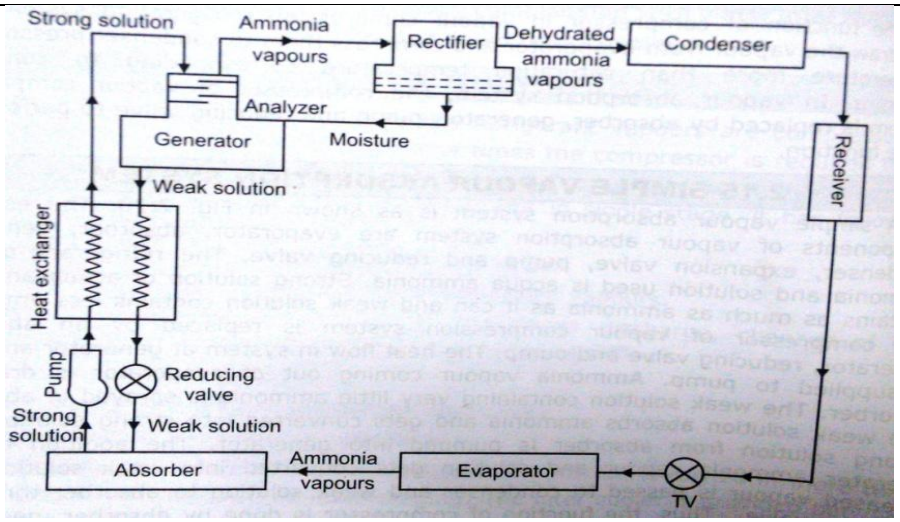


4marks

Fig. Vapour compression refrigeration cycle

	b.	**Superheating:** Increasing the temperature of refrigerant vapour more than saturation temperature in evaporator is known as superheating. Yes it is desirable, because if some liquid refrigerant enters the suction line of compressor, due to wet compression, lubricating oil present in compressor will be washed off causing more wear and tear of compressor and also life of compressor reduces. Therefore, due to superheating suction temperature of compressor increases and it increases compressor power and life of compressor also.  **Fig. Superheating** --- **Necessity:** i. To reduce frictional losses. ii. To reduce the size of cylinder. iii. To reduce running cost of compressor. iv. To increase volumetric efficiency of compressor. **Advantages:** **i.** The volumetric efficiency of compressor increases. ii. The cost of compressor reduces. iii. It reduces leakage of refrigerant. iv. Work done per kg of refrigerant is reduces. v. It gives uniform torque therefore smaller flywheel may be used.	(2M to explain and 2M diagram) 2marks 2marks
	c.		

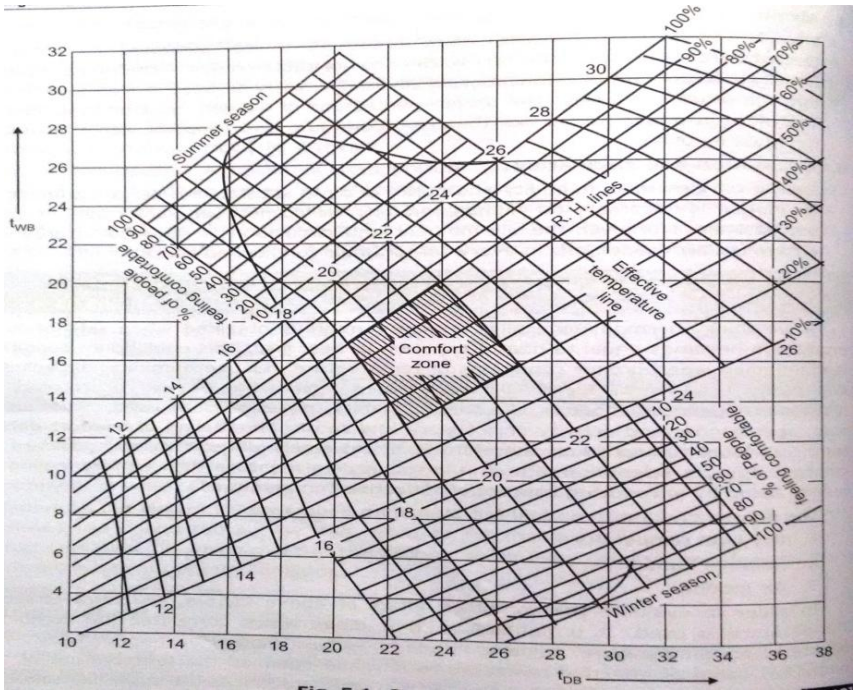
d.



Practical vapour absorption cycle

4marks

e.



4marks

f.

i) Photographic industry

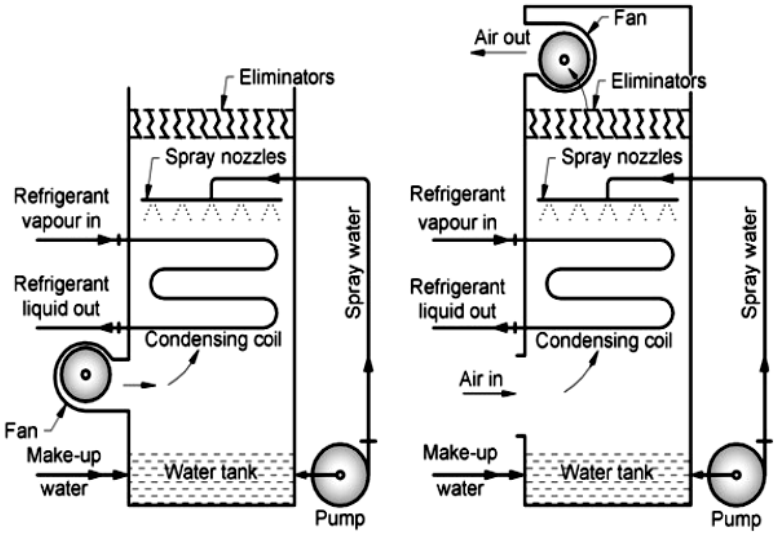
ii) Textile industry

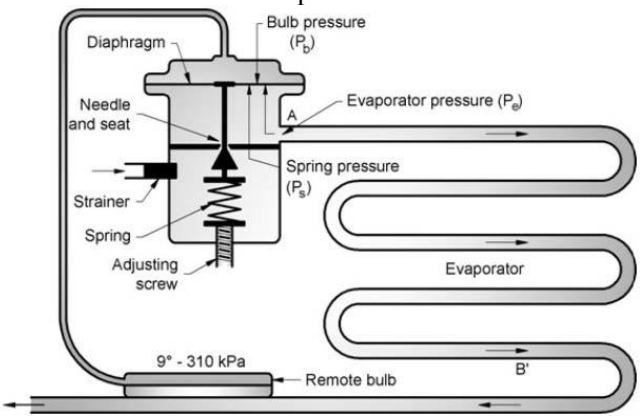
iii) Printing industry

iv) Machine tool industry

(1mark for each)

3	a)	Classification of compressor (Any four points) **1) According to the method of compression:** i)Reciprocating compressor ii)Rotary compressor iii)Centrifugal compressor **2) According to number of stages:** i) Single stage compressor : Delivery pressure up to 10 bar ii) Multistage compressor: Delivery pressure above 10 bar. 3) **According to number of cylinder**: i) Single cylinder compressor ii) Multi cylinder compressor 4) **According to method of cooling**: i) Air cooled compressor ii) Water cooled compressor 5) **According to action of air:** i) Single acting compressor ii)Double acting compressor 6) **According to capacity**: i) Low capacity ii) Medium capacity iii) High capacity. 7) **According to the method of drive employed**: i) Direct drive compressor ii) Belt drive compressor.	4 Marks
	b)	**Compare between Open type and Hermetical sealed compressor** **Open type compressors**. **(2 Marks for Four points)** • Most common problem is failure of shaft seal assembly and leakage of refrigerant. • Due to leakage of refrigerant, the recurring cost for open type compressor is high. • Motors used for Open compressors are air-cooled. • Reduces the efficiency and reliability of the motors. • Motors of Open compressors have to be erected and assembled at site. This requires precise alignment of the motor and compressor • Motors of Open compressors reject heat in the plant room • This compressor normally requires heavy foundations and grouting to be done at site. • simple construction • Application for capacity of plants ex. Cold storage .central air conditioning **Hermetically sealed type compressors.** **(2 Marks for Four points)** • Do not need any shaft seal assembly, because the compressor and the motor are mounted on a common shaft and in a common housing. • there is no chance of leakage of costly refrigerant gas through the seals is less costly • Semi-hermetic compressor motors are refrigerant gas cooled. • high efficiency and reliability of the compressor motor • Motor is enclosed under shell. Problem does not arise in case of hermetic compressors. • The motor heat is rejected directly into the cooling tower. • Hermetic compressors are factory assembled and mounted on the structure / skid and do not require any foundation or grouting. • With many redundant safety features built in the system like overheat and overload protection, hermetic motors do not face serious problems. • Application for smaller capacity plant like refrigerator ,air conditioning unit	4 Marks

	c)	Principle of evaporative condenser: (draw any one sketch of the following)  **(a) Forced circulation** **(b) Induced circulation** The evaporative condenser perform both the combined function of a water cooled condenser and a cooling tower. *In its operation the water is pumped from sump to spray header and sprayed through nozzles over the condenser coil through which hot refrigerant from compressor is passing. *Heat is transferred from refrigerant in the condenser into the water that is outside the surface of tuber. *A fan is also used which draws air from the bottom side of condenser and discharges out at the top of condenser. *The air causes the water from the surface of the condenser coils to evaporate and absorb the latent heat of evaporation from the remaining water to cool it. *Since heat for vaporizing the water is taken from the refrigerant, therefore the vapour refrigerant condenses into liquid refrigerant. *The cold water that drops down into a sump is recalculated. A float valve keeps a check of water level. *The eliminator is provided above the spray header to stop particles of water escaping along with the discharge air.	**(Sketch 2 Marks and Explanation 2 Marks)**
3.	d	Capillary tube commonly use (Any four points) 1.It is inexpensive. 2.It does not have any moving parts hence it does not require maintenance 3.Capillary tube provides an open connection between condenser and the evaporator hence during off-cycle, pressure equalization occurs between condenser and evaporator. This reduces the starting torque requirement of the motor since the motor starts with same pressure on the two sides of the compressor. Hence, a motor with low starting torque. 4.Ideal for hermetic compressor based systems, which are critically charged and factory assembled.	4Marks

	e)	Thermostatic expansion valve The operation of this valve is based on the principle of constant degree of superheat for the vapor at or exists i.e. by controlling the flow of liquid refrigerant through the evaporator. • The thermostatic expansion valve consists of a needle valve and a seat, a metallic diaphragm, spring and adjusting screw. • In addition to this it has a feeder or thermal bulb which is mounted on the suction line of compressor near the outlet of the evaporator coil. • The filler bulb is partly filled with the same liquid refrigerant as used in refrigeration system. • The opening or closing of valve is depended upon the force on the diagram. **Operation :** • The remote bulb is charged with fluid which is open on one side of the diaphragm through capillary tube is firmly to evaporate outlet. • The pressure (Pb) of the fluid in the bulb tends to open the valve. This pressure is balanced by pressure due to spring (PS) and in the evaporator (Pe). • If the evaporator temperature is high or the load on the evaporator increase, more fluid from feeler bulb will be vapourised and bulb pressure will rises which exert this force on diaphragm. • This will widen the valve opening and the refrigerant flow will increase to meet load demand and if load on evaporator decreases reverse action takes place.  Fig. Thermostatic expansion valve	4Marks **Sketch 2 Marks and Explanation 2 Marks)**
3.	f)	Difference between air cooled and water cooled condenser (any four points)	4 Marks

Air cooled condenser	Water cooled condenser
1.Construction is very simple	1.Construction is complicated
2.Initial cost is less	2.Initial cost is high
3.Maintenance cost is low	3.Maintenance cost is high
4. There is no handling problem with air cooled condenser.	4. There is handling problem with water cooled condenser.
5. Do not required piping arrangements for carrying air.	5. Required piping arrangements for carrying water
6.No problem in disposing of used air.	6.Problem in disposing of used water
7.No corrosion	7. corrosion occures

		8.Low heat transfer capacity	8.High heat transfer capacity	
		9. Used Low capacity plants	9. Used high capacity plants	
		10.High flexibility	10.Low flexibility	

4 a) i)RH(Relative humidity):It is the a ratio 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. — 4Marks

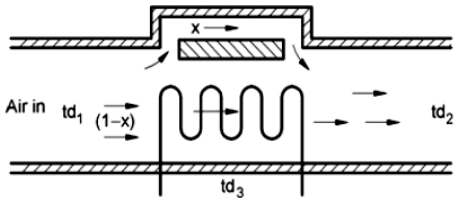
ii)DBT:It is the temperature of air recorded by a thermometer ,when it is not affect by the moisture present in the air.

iii)DPT:It is the temperature of air recorded by a thermometer ,when the moisture present in it begins to condense.

iv)Specific humidity: it is the mass of water vapour present in one kg of dry air.

b) **Concept of sensible heat factor and bypass factor with suitable sketches**

Bypass factor : When air passes over a coil, some of it say "X" just by-passes unaffected while the remaining (1 - X) kg comes in direct contact with the coil. This by-pass process of air is measured in terms of by-pass factor. — 2 Marks



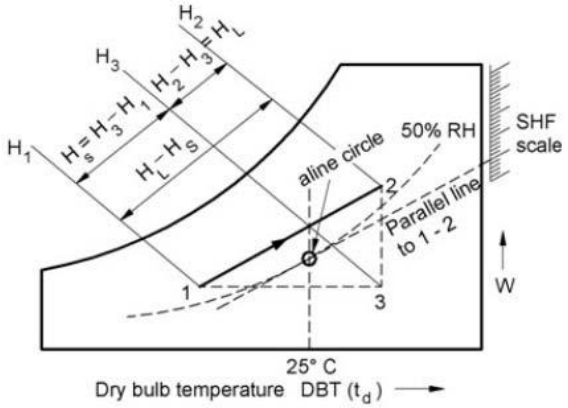
$X \cdot Cp_m td_1 + (1 - X) Cp_m td_3 = 1 \cdot Cpm td2$ (Cpm= specific humid heat)

$X (td_3 - td_1) = (td_3 - td_2)$

$x = (td_3 - td_2)/(td_3 - td_1)$ where X is by pass air

Sensible Heat Factor : — 2 Marks

The ratio of sensible heat to total heat added is known as sensible heat factor (SHF) process of sensible heating on the psychometric chart is shown by a horizontal line 1 -2 extending from left to right.Sensible heat factor = Sensible heat / (Sensible heat + Latent heat)



4. c) **List different types of dehumidifiers. Describe most commonly used type with sketch**

Ans: Different types of dehumidifiers:

i) Spray type dehumidifier ii) Cooling coil type dehumidifier

(1 Mark)

i) Spray type dehumidifier :

(Sketch 1.5 Marks and Explanation 1.5 Marks)

- This type of dehumidifier is similar with humidifier with an exception that the water used for spraying purpose is having temperature below the dew point temperature of air.
- The outside fresh air enters through filter which removes the dust particle.
- This air is then passed through cold water having temperature below dew point temperature of the room air.
  By this the outside air is cooled below its dew point temperature (DPT) and thus excess moisture is removed. However, the dry bulb temperature of air leaving the eliminator is much below the DBT of desired condition space.
- Hence an heater is used to maintain the temperature through which air is passed to condition space.
- A refrigeration system is used to cool the water supply the and an overflow pipe is required to drain the added water.

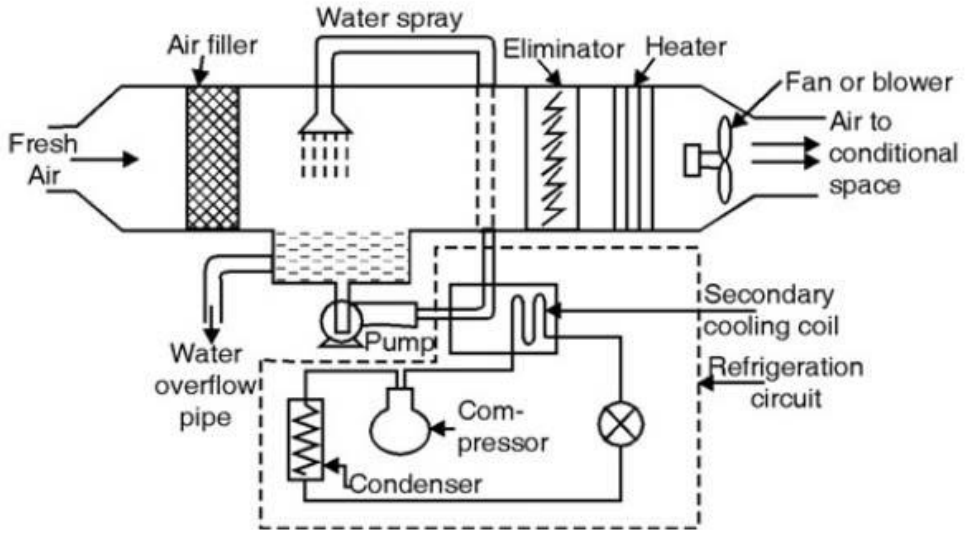


Fig. **Spray type Dehumidifier**

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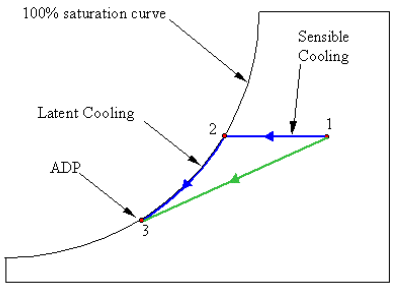
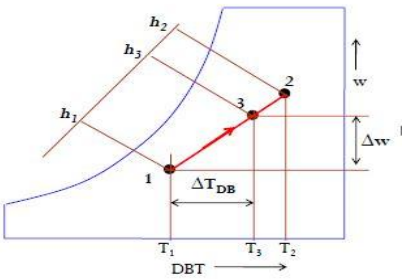
d) Show cooling process on psychometric charts

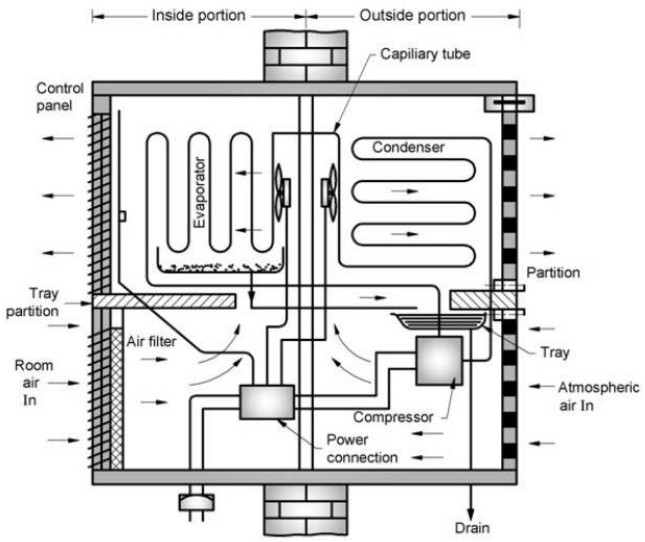
i) Cooling with dehumidification: ii) Heating with humidification:

2 Marks each

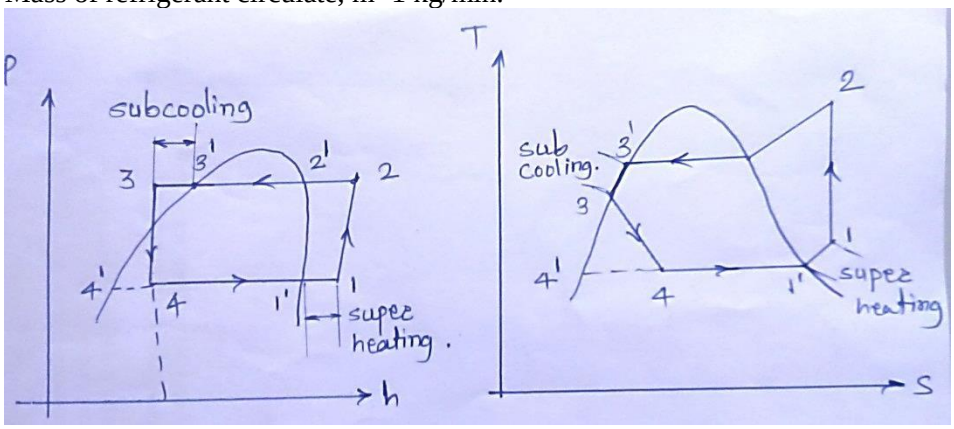


PSYCHROMETRIC CHART SHOWING COOLING AND DEHUMIDIFICATION



4.	e)	**working of window air conditioning system:**  **Working :** • First the low pressure, low temperature refrigerant vapour is sucked by hermitically sealed compressor and compressed to high pressure, high temperature and it is then discharged to condenser to reject the latent heat. • The liquid refrigerant passes through the filter into the capillary tube where it is throttled and the flows to the evaporator coil at lower pressure. • This liquid refrigerant than rapidly boils at low pressure and picks up evaporation enthalpy from the evaporator surface. • A fan or blower is used to drive the air from room through air filter from the lower part of the unit and forces it to flow over the evaporator coil. • The temperature of the cooling coil absorbs the heat from the air and is circulated back into the conditioned room. • Due to this the temperature of room air is reduced hence air becomes chilled and circulated back into the conditioned room. • But due to reduction in the temperature of the air dew is formed on the surface of the cooling coil. For this purpose the temperature of the cooling coil is lower than then the dew point temperature of the air. • This moisture present in circulating air is removed and flows from coil surface and drips in the tray at the bottom. This moisture in the tray (pan) evaporates to some extent which helps in cooling the compressor and condenser. • This type of air conditioning is used for office, bed room, drawing office etc.	(Sketch 2 Marks and Working 2 Marks)
4.	f)	Properties insulating materials : (any four points) **A)** Thermal properties 1. Low thermal conductivity: Thermal conductivity of insulating material should be as low as possible to reduce the thickness of material. 2. High permanence: Materials may disintegrate as a result of internal chemical activity. Resistance to above activity is permanence. It should be high B) Mechanical Properties: 1) It should have high strength in compression tension shear and impact as it is carrying some loads 2) It should be light weight. C) Physical properties : 1) It should be odorless	4 Marks

		2) It should be fire proof. 3) It should be chemically inert. D) Others 1) Low cost 2) Easy available 3) More durability	
5		**Attempt any Two**	8x2=16
	(a)	**What is sensible and Latent heat gain? List the source of sensible and latent heat gain in restaurant.** **Ans:** **Sensible heat gain-**When there is direct addition of heat to the enclosed space, a gain in sensible heat is said to be occur. **Latent heat gain-**When there is addition of water vapour to the air of enclosed space, a gain in latent heat is said to be occur. **List of Heat sources in Restaurant- (Here assume a large restaurant 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 smoke concentration, 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 coffee braver, egg boiler, grinder, food warmer ,toaster etc. Appliances may be gas fire or steam heated. Heat gain can be calculated as- Q = (Total Wattage *use factor*Allowance Factor). **6.Heat gain from power equipment's-** Such as motor, fan or other equipment of this type also add heat in the air conditioned space- Ex-Electric motor used ,then heat added in KW Q = (rating of motor (KW)* Load Factor)/Motor Efficiency. **7.Heat gain from Occupants-** The human body in cooled space constitutes cooling load of sensible and latent heat. Heat gain depends on average number of people present in restaurant and activity of person.	1mark 1mark 01 mark for each source. (any six)

	(b)	**Refrigeration system works on VCR system. Enthalpies at various points are given below:** **Compressor inlet=1460 kJ/kg** **Compressor out let =1796 kJ/kg** **Inlet to expansion valve =322 kJ/kg** **The refrigerant is to superheated by 15 ^{0}C before it enters the compressor and sub cooled by 3 ^{0} C before expansion, Show the cycle on P-h and T-S chart. Find-(i) COP, (ii) Power required for 1 kg of refrigerant circulated /min.** **Solution:** given data – h_1=1460 kJ/kg h_2=1796 kJ/kg h_3=322 kJ/kg Mass of refrigerant circulate, m=1 kg/min.  (i).COP=$(h_1-h_4)/(h_2-h_1)$ =(1460-322)/(1796-1460) =3.386 (ii) Power required per kg refrigerant circulated per minute is, W.D.=$m(h_2-h_1)$ =1*(1796-1460) Unit conversion-(kg/min)*(kJ/kg)=kJ/min =336 kJ/min =336/60 kJ/sec =5.6 kJ/sec =5.6 kW. As …..J/s=W	(02 marks for each figure) 02 marks 02 marks
	(c)	**Explain Automobile air –conditioning system.** **Ans:** Air conditioners work on the principle that "liquids absorb heat when they become a vapour (evaporate). Low pressure R134a vapor entering the compressor is compressed to become high pressure/temperature R134a vapor. This is then circulated along with lubricant oil to the condenser. As the high pressure/temperature vapor travels through the condenser, heat is released to the cooler ambient air passing over the condenser tubes condensing the vapor into a liquid. This high pressure/temperature liquid then travels through the filter drier onto the 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. The R134a is now under low pressure/temperature vapor 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.	Working Principle-4marks

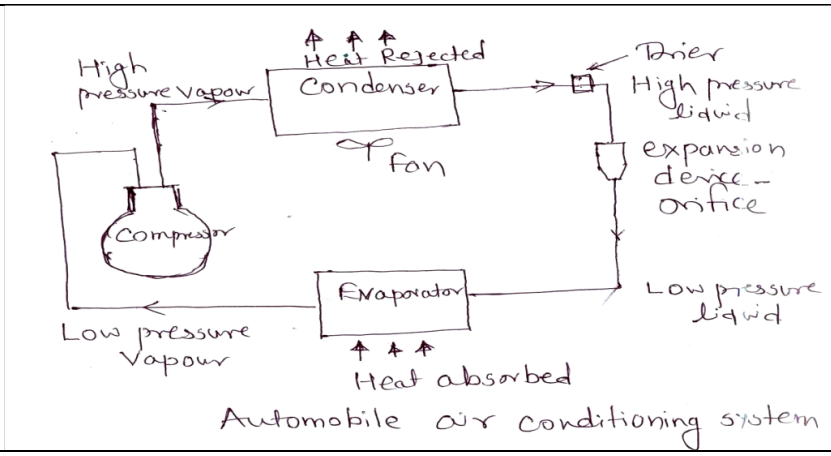


Diagram- 4 marks

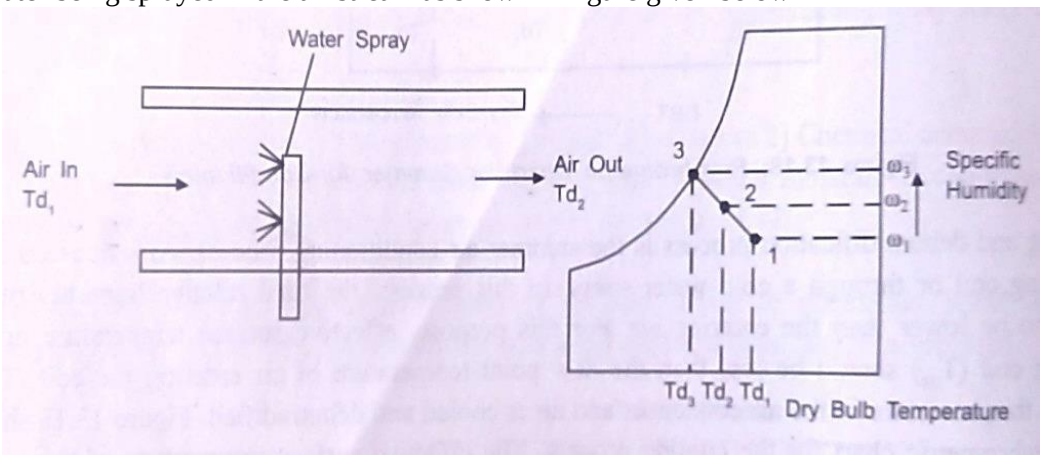
06 (a)

Attempt any TWO

Explain Air conditioning system for Hot and Dry weather with neat sketch. Represent it on psychrometric chart. (04 marks for sketch and 04marks for explanations)

Ans:

For hot and dry weather condition; air conditioning with cooling with humidification will give better comfort. In cooling with dehumidification process, air is passed through an insulated chamber with water being sprayed in the air stream as shown in figure given below-



02 marks for each figure)

(03 marks)

Let T_{d1}=Dry Bulb Temperature of air entering the apparatus.

T_{d2}=Dry Bulb Temperature of air leaving the apparatus.

The water temperature is higher than Dew Point temperature of entering air (T_{dp1}), but lower than the DBT of entering air (T_{d1}).The air is now cooled and humidified Since no heat is supplied or rejected, the same water is re circulates and adiabatic condition can be achieved. In ideal case the exit temperature of air should be equal to T_{d3}.However due to imperfect humidification, we obtain the temperature $T_{d2.}$

(01 marks)

Humidifying efficiency=$(T_{d1}-T_{d2}) / (T_{d1}-T_{d3})$

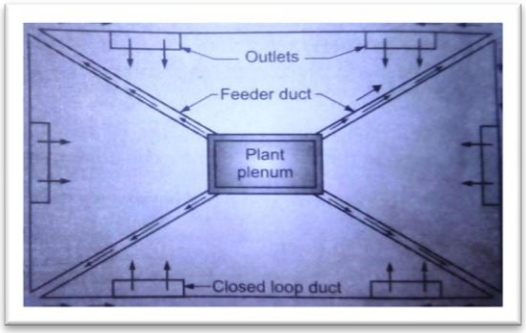
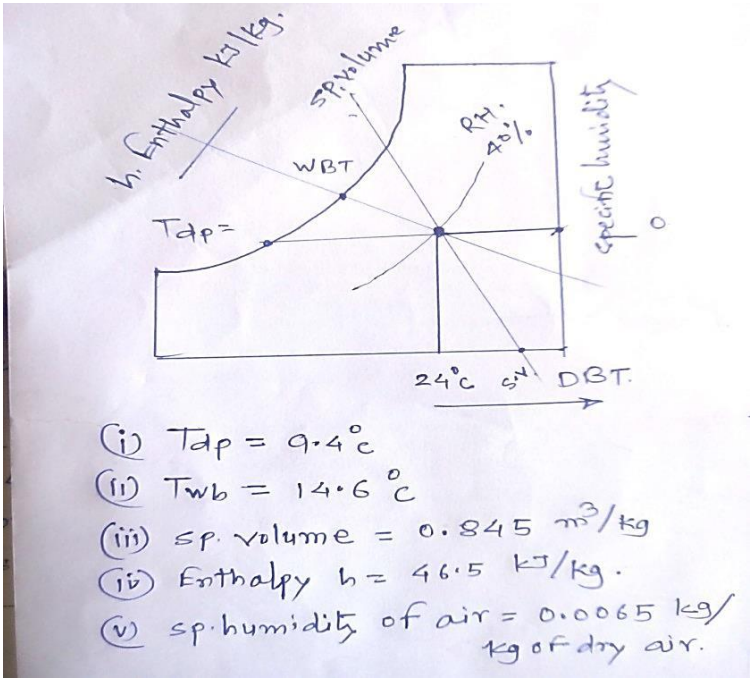
(b)

List the three duct system (duct layout) and describe closed perimeter duct system. Draw the relevant sketch for the same.

Ans:

The air distribution system mainly consists of supply ducts and return ducts. The most commonly used duct system are,

01 mark for each.(03)

		1. Closed perimeter or Loop perimeter system. 2. Radial perimeter system. 3. Extended plenum system. **Closed Perimeter system-** 1. The air conditioning unit is placed in the basement of building and the conditioned air from central air conditioning plan is brought to central plenum. 2. From central plenum, it is carried to several feeder ducts to a common continuous closed loop around the perimeter of building. 3. The outlets then supply conditioned air to the room.  	Explanation 03 marks Diagram 2 marks
	(c)	**With the help of psychrometric chart find properties of air at 24 ^{0}C DBT and 40% Relative humidity.** **Ans:**  	Diagram 03 marks Solution 05 marks