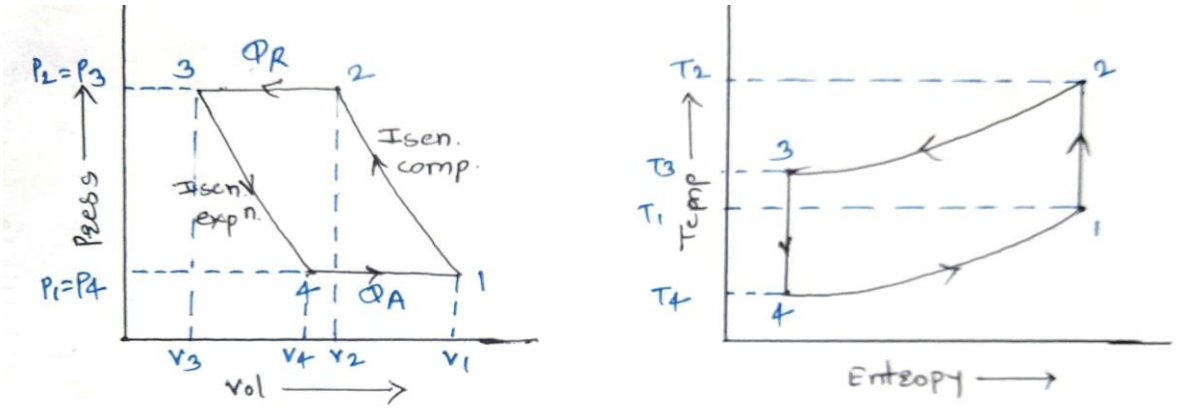
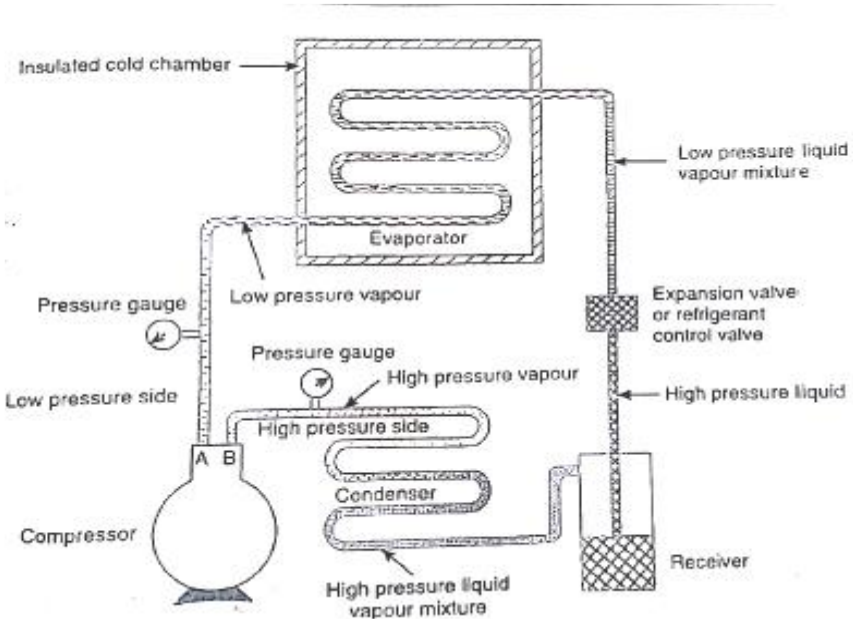
WINTER – 19 EXAMINATION

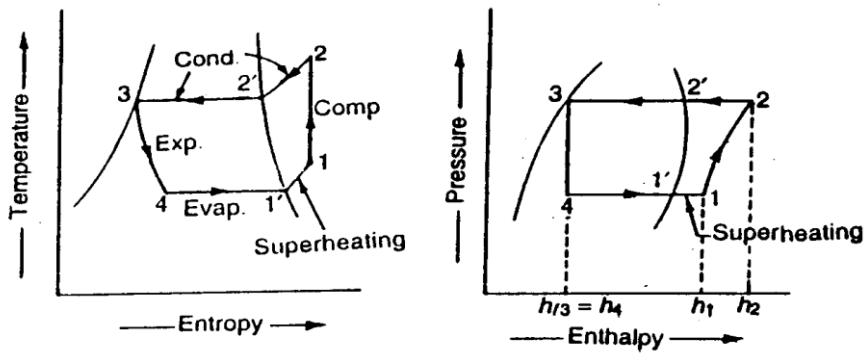
Subject Name: Refrigeration and Airconditioning **Model Answer** **Subject Code: 17612**

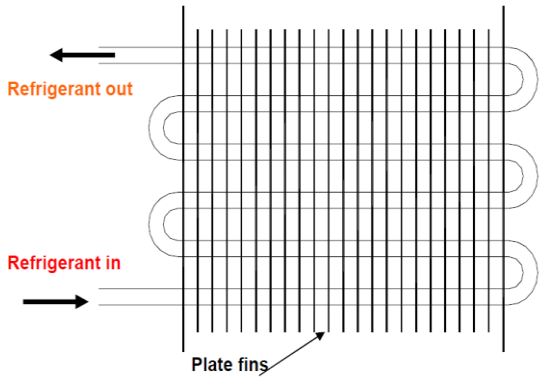
Important Instructions to examiners:

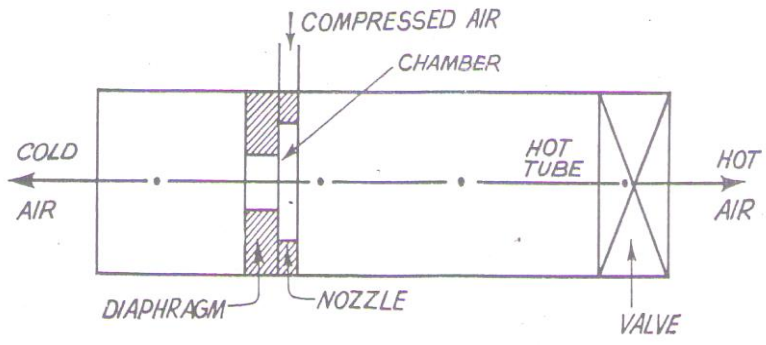
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling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

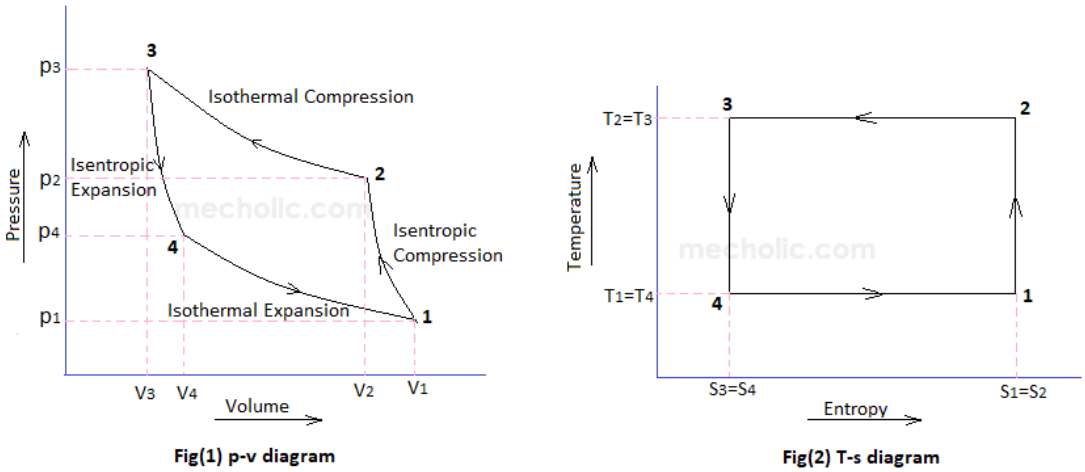
Q. No.	Sub Q. N.	Answer	Marking Scheme
1	**(a)**	**i) Energy efficiency ratio (EER):** Energy Efficiency Ratio, or EER, is a way to exhibit how well an air-conditioner is operating based on the power being used. EER = Capacity / Power **ii) Refrigerating effect:** It is the amount of heat energy removed per unit time from the space to be cooled by the refrigeration process. It is also called as capacity of refrigerator. It is expressed in KW or KJ/S.	**2mark** **2mark**
	(b)	**Green House Effect:-** It is earth ability to retain heat. When the sun 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, carbon dioxide (CO2), methane (CH4), chlorofluorocarbons (CFCs) and hydrogenated chlorofluorocarbons (HCFCs), tropospheric ozone (O3), and nitrous oxide (N2O), trap same heat in lower part of earth's atmosphere. Without the naturally occurring greenhouse gases (principally water vapor and CO2), the earth's average temperature would be nearly 35°C (63°F) colder, and the planet would be much less suitable for human life. **Global Warming:-** Due to "Ozone Layer Depletion" the atmosphere allows a large percentage of the rays of visible light from the sun to reach the earth surface and heat it. Out of the incident radiation some infrared radiation is trapped by the earth atmosphere due to molecules of carbon dioxide and water vapour in the atmosphere and causes the earth"s surface and lower atmospheric layer to warm to high temperature. This is called as global warming.	**2mark** **2mark**

	(c)	**Draw Bell-Coleman cycle on PV and TS diagram and label the processes.**  a) P-V diagram b) T-S diagram. Processes:- Process 1-2 → Isentropic compression process Process 2-3 → constant pressure Heat rejection (cooling) Process 3-4 → Isentropic expansion Process 4-1 → constant pressure Heat absorbtion	02 marks for P-V and 02 mark for T-S dig.
	(d)	**Simple vapour compression refrigeration system-**  **Fig- simple vapour compression cycle**	Sketch03 mark naming01 mark

	(e)	**Effect Of Superheating of suction Vapour-(before compression)**  A vapour compression cycle with superheated vapour before compression is shown on T-s and p-h diagrams respectively. In this cycle, the evaporation starts at point 4 and continues upto point 1', when it is dry saturated. The vapour is now superheated before entering the compressor upto the point 1. The vapor superheat has the following effects on the refrigeration cycle: (a) It increases the refrigeration effect per unit mass of the refrigerant from H1' - H4 to H1 - H4. (b) The specific volume increases from V1' to V1. This implies the reduction in mass flow rate for the same displacement volume of the compressor. (c) The energy for compression of refrigerant vapour will increase due to the diverging nature of the isentropic lines. (d) It is a usual practice to admit slightly superheated vapor before the beginning of compression to avoid the possibility of wet compression. Wet compression is undesirable as there may be accumulation of liquid inside the cylinder, which in turn will wash away the lubricant resulting in sever mechanical difficulties. Thus, to avoid this, a 5 to 20 K superheat of the refrigerant is always desirable.	**01 mark for sketch** **03 mark for explanation**
	(f)	**Hermetic sealed compressor:** A hermetic sealed compressor is one in which both compressor and motor are confined in a single outer welded steel shell. The motor and compressor are directly coupled on the same shaft, with the motor inside the refrigeration circuit. Thus the need for a shaft seal	**$2^{1/2}$ marks**

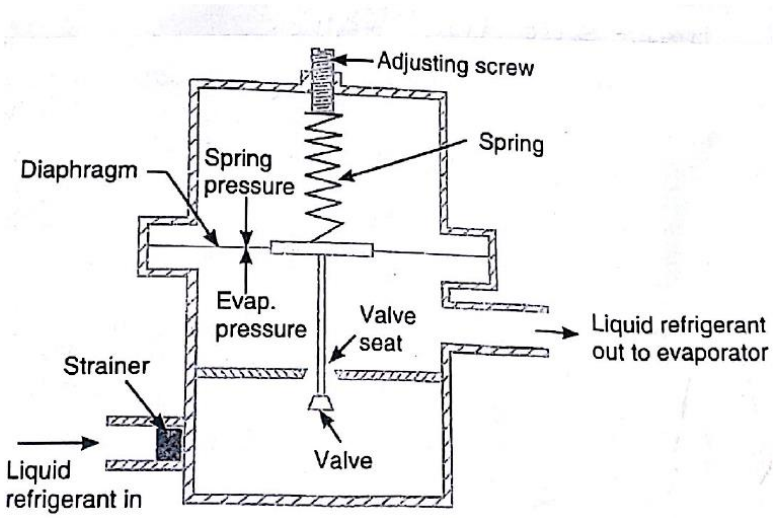
		with the consequent refrigerant leakage problem was eliminated. All the refrigerant pipeline connections to the outer steel shell are by welding or brazing. The electrical conductors to the motor are taken out of the steel shell by sealed terminals made of fused glass. Hermetic compressors are ideal for small refrigeration systems, where continuous maintenance (replenishing refrigerant and oil charge etc) cannot be ensured. Hence they are widely used in domestic refrigerators, room air conditioners etc. Since, the motor is in the refrigerant circuit, the efficiency of hermetic compressor based systems is lower as the heat dissipated by the motor and compressor becomes a part of the system load. Also material compatibility between the electrical winding, refrigerant and oil must be ensured. Since the complete system is kept in a welded steel shell, the hermetic compressors are not meant for servicing. A variation of hermetic compressor is a semi-hermetic compressor, in which the bolted construction offers limited serviceability. **Advantages-** 1) The hermetically sealed compressors can be moved easily from one place to the other place, they are highly portable. More compact unit and required less space. 2) It is less noisy than ordinary system. 3) No coupling, belt or pulley is involved, the maintenance is lesser. 4) The lubrication system of the hermetically sealed compressor is inherent and no external lubrication is required, unless the fresh gas charging is done. 5) The installation of the hermetically sealed compressor is very easy. 6) Hermetically sealed compressors have very long life. 7) The leakage of refrigerant is completely avoided.	**$1^{1/2}$ marks for any 03**
	(g)	**Air cooled condenser-**  Fig.	**02 mark fig**

		Working- The atmospheric air is used as a medium of heat transfer in air cooled condenser. The heat rejected by the refrigerant is received by the air. The air circulation over an air cooled condenser may be either natural convection or by the action of blower or fan. Accordingly, they are classified as natural draft or mechanical draft condenser. The air cooled condenser consists of finned tubing of copper or other suitable metal in which the vapour of the refrigerant enters from the top and the liquid refrigerant leaves from the bottom of the condenser. The heat transfer area, temperature of the air, velocity of the air, overall heat transfer co-efficient etc. are important parameters affecting the performance of the condenser. This type of condenser is used for relatively small capacity system as heat rejection rate per unit area of the tube is less as compared to other type of condensers.	**02marks**
(2)	**(a)**	**Vortex tube refrigeration-**  **Fig- vortex tube ref^{n}** **Working: -** Vortex tube is simple device of producing cold. A compressed air is passed tangentially through nozzle. Here air velocity increases due to expansion and particular shape of nozzle. A vortex flow is created in the chamber and air flows in spiral motion along periphery of hot side. This flow is restricted by valve. If the pressure of air near valve is increased by partly closing of valve, a reversed axial flow through the core of hot side starts from high pressure to low pressure region. During this process, energy transfer takes	**Fig.02 mark** **Working 02 mark**

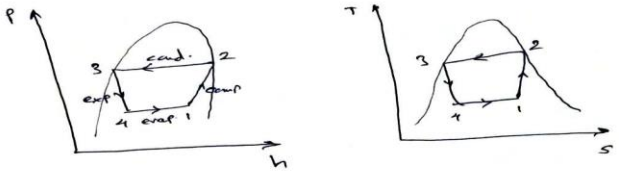
		place between reversed stream and forward stream through the core gets cooled below the inlet temperature of the air in the vortex tube while air stream in forward direction gets heated. The cold stream is escaped through the diaphragm hole into the cold side, while hot stream is passed through the opening valve.	
	(b)	**Desirable properties of refrigerant.** a) Boiling point at atmospheric pressure should be low. b) Freezing point at atmospheric pressure should be low. c) Latent heat of vaporization of refrigerant must be high. d) Critical temperature should be high. e) It should not have corrosive action with system material. f) It should not be flammable & explosive. g) It should not be toxic. h) It leak should be easily detectable. i) It should have positive condensing pressure. j) It should have satisfactory heat transfer coefficient. k) It should have high thermal conductivity. l) It should have chemical stability.	**04 marks for any eight properties**
	(c)	**Reversed Carnot cycle-**  Fig(1) p-v diagram Fig(2) T-s diagram **Fig:- P-V & T-S dig**	**T-S diagram 02 Marks and P-V diagram 02 Marks**

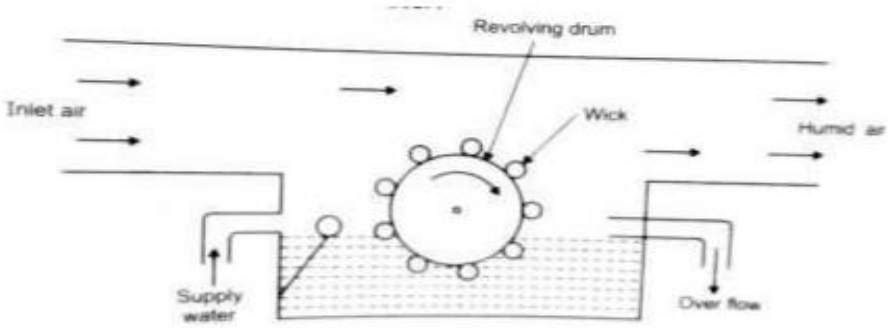
	(d)	**Dry compression**- Dry compression means completely dry vapour form of refrigerant enters the compressor before compression. In this removal of heat during evaporation process should be continued till the vapour gets dry saturated or slightly superheated. Then the entire compression will take place in the superheated region such type of compression is known as dry compression. **Wet compression**- Wet compression is the case where some liquid portion of refrigerant enters the compressor along with vapour part of refrigerant before compression. **Effect of wet compression on compressor**- a) The liquid form of refrigerant enters into the compressor it will washers away the lubricant inside the compressor and leads to damage of compressor. b) Compressor blade erosion due to impingement of water droplets. c) liquid droplet mix with lubricating oil and pass to condenser and decrease heat transfer rate from refrigerant to condensing medium. d) C.O.P.is lower for the entire system. so it's always preferred to go for dry compression.	**01mark** **01mark** **02mark**
	(e)		**04 marks for any two**

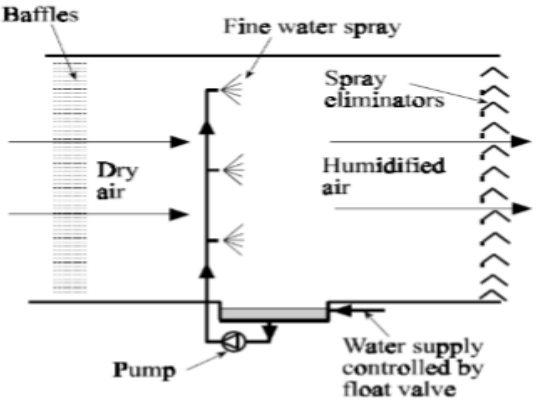
Sr.No.	Simple NH3 absorption system	Practical NH3 absorption system
1	It consists of basic component as an absorber, pump, generator, expansion valve and also condenser, evaporator, receiver.	Along with basic component system is fitted with accessories as an analyzer, rectifier and two heat exchanger.
2	C.O.P is lower.	C.O.P. is higher.
3	Capacity is small	Capacity is large.
4	Energy saving is not possible.	Energy saving in generator is possible.
5	For desire cooling effect more time is required.	For desire cooling effect less time is required.
6	Chocking of evaporator and expansion valve may occur due to water vapour.	Chocking of evaporator and expansion valve avoided as water vapour completely removed in rectifier.

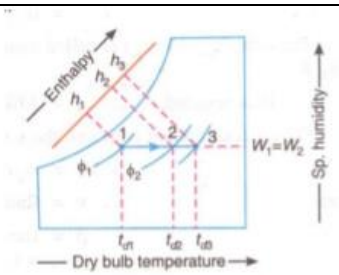
	(f)	**Automatic Expansion valve-**  **Fig- Automatic expansion valve.**	**03 mark Fig 01mark label**

Q. No.	Sub Q. N.	Answer	Marking Scheme
3.	a)	i) **Expansion valve** **Function :** i) To reduce the pressure of refrigerant form condenser pressure to evaporator pressure by throttling. ii) An expansion valve is a component in refrigeration and air conditioning systems that controls the amount of refrigerant flow into the evaporator thereby controlling the superheat at the outlet of the evaporator. **Types of Expansion devices** 1. Thermostatic Expansion Valve 2. Capillary tube Expansion Valve 3. Hand operated Expansion Valve 4. Automatic or Constant Pressure Expansion Valve 5. Float expansion Valve ii) **Evaporator Capacity:** Capacity of evaporator is defined as the number of kilograms of water evaporated per hour. The capacity of an evaporator depends upon the temperature of the feed fluid.	2 Marks 2 Marks 2 Marks

Q. No.	Sub Q. N.	Answer	Marking Scheme
3.	a)ii	The rate of heat transfer Q through the heating surface of evaporator is the product of heat transfer coefficient, heat transfer surface area and the overall temperature drop. Therefore $Q = U \times A \times \Delta T$ Where Q = Rate of heat transfer A = area of the heat transfer surface ΔT = overall temperature drop The capacity of an evaporator depends upon the temperature of the feed solution. If the feed solution is at the boiling temperature corresponding to the pressure in vapor space of an evaporator, all the heat supplied will be utilized for evaporation, thus increasing the capacity of evaporator.	2 Marks
	b)	 As given Enthalpy at exit = 298.9 kJ/kg = h_3 Consider the process 3-4, throttling process Enthalpy before throttling = Enthalpy after throttling $h_3 = h_4 = 298.9$ kJ/kg Enthalpy at the exit of comp = $h_2 = h_3 + (h_2 - h_3)$ $= 298.9 + 1166.94$ $= 1465.84$ kJ/kg consider process 1-2 $PV^{n} = C$ Entropy before comp = Entropy after comp. $S_1 = S_2$ $S_4' + x_1 \frac{h_{fg}}{T} = S_3 + \frac{h_{fg}}{T}$ $0.5443 + x_1 \frac{1297.68}{263} = 1.1242 + \frac{1166.94}{298}$ $\therefore x_1 = 0.91$ ∴ Enthalpy at comp. Inlet $h_1 = h_4' + x_1 (h_1' - h_4')$ $= 135.37 + 0.91 \times 1297.68$ $h_1 = 1316.26$ kJ/kg $\therefore COP = \frac{h_1 - h_4}{h_2 - h_1}$ $= \frac{1316.26 - 298.9}{1465.84 - 1316.26}$ $COP = 6.8$	2 marks 2 marks 4 marks

Q. No.	Sub Q. N.	Answer	Marking Scheme
3.	c)	**Humidifier** 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. **Revolving wick type humidifier:**  - It Consist of a rotating drum - Wicks are provided on periphery of drum - Air Comes from one side and leaves from other side - When drum rotates; the wetted wick comes in contact with air and humidifies it.	2 Marks 2 Marks 2 Marks 2 Marks

Q. No.	Sub Q. N.	Answer	Marking Scheme
4.	a)	**Air Washer** - Air Washers are used mostly in industrial humidification. -As the name implies they provide the dual function of humidifying the airstream and at the same time washing out some dust and odours. -The airstream is made to flow smoothly by passing between baffle plates (as shown in figure), it then passes through a fine mist of water droplets created by a spray head. -This provides the contact between the liquid water and the air necessary for evaporation to take place. – -Spray eliminators are placed downstream from the humidifier to prevent the carriage of liquid water further down the ducting. -Evaporation of the water cools the airstream and humidifies air.  	2 Marks 2 Marks
	b)	**Sensible Heating** Sensible heating process is opposite to sensible cooling process. In sensible heating process the temperature of air is increased without changing its moisture content. During this process the sensible heat, DB and WB temperature of the air increases while latent of air, and the DP point temperature of the air remains constant.	2 Marks

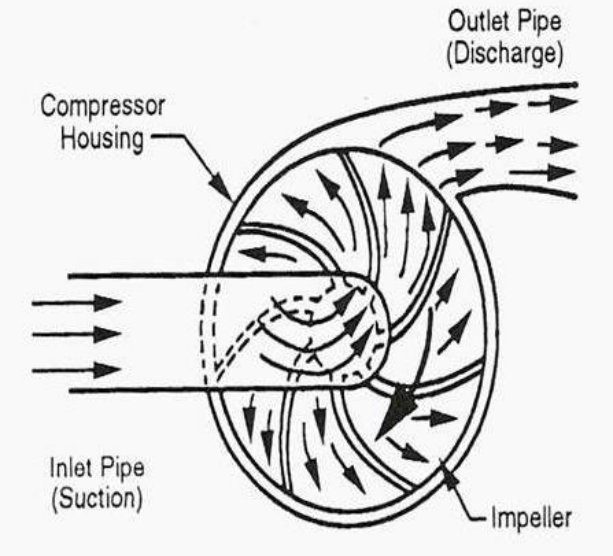
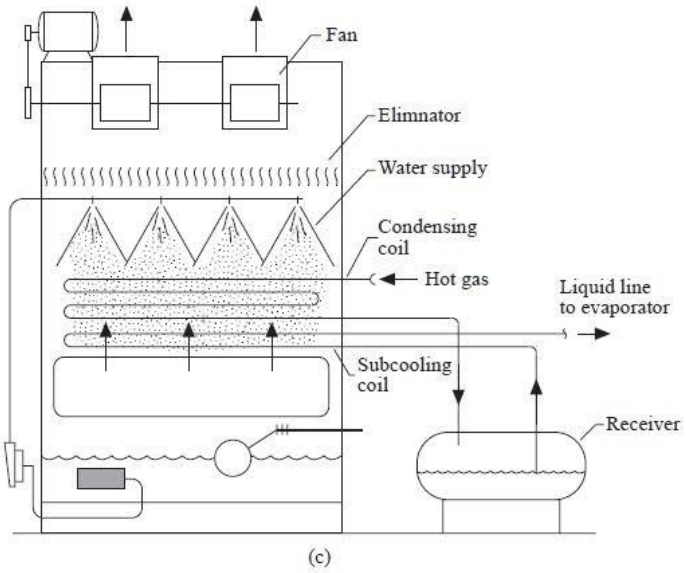
			2 Marks
4.	c)	Following factors are affecting on human comfort. **1. Temperature of air:** In air conditioning, the control of temperature means the maintenance of any desired temperature within an enclosed space even though the temperature of the outside air is above or below the desired room temperature. 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 210C 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.	1 Marks for each point

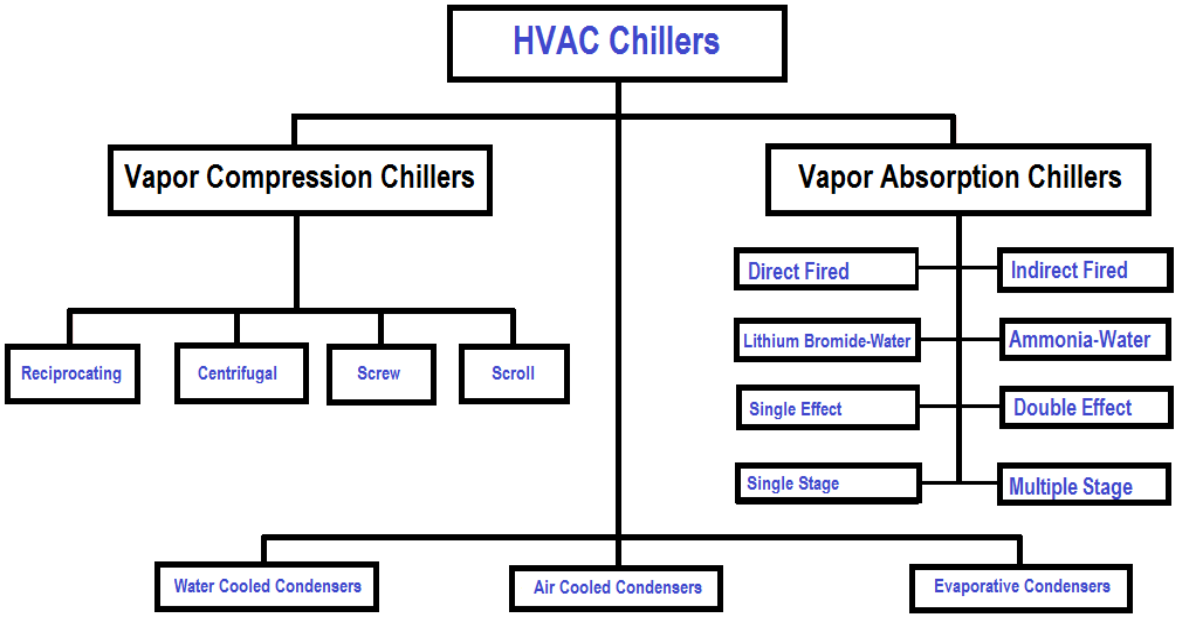
	d)	**Material used for ducts :** Galvanized steel, Aluminum (Al), Polyurethane and phenolic insulation panels, Fiberglass duct board PVC low profile ducting **Desirable Properties :** -Vibration isolators -Volume control dampers -Smoke and fire dampers -Flexible -Water proof	2 Marks 2 Marks

Q. No.	Sub Q. N.	Answer	Marking Scheme
4.	e)	Fan Classification **1. Centrifugal fan:** i) Forward blade Centrifugal fan ii) Radial blade Centrifugal fan iii) Backward blade Centrifugal fan **2. Axial flow fan:** i) Propeller fan ii) Tube axial fan 3. Vane axial fan.	4 Marks

	f)	**Properties of Insulating Material :** **i. Thermal conductivity**: Thermal conductivity of insulating material should be as possible to reduce the thickness of material. **ii. Nonflammable**: Insulating material should be fire proof and nonflammable for safety purpose. **iii. Odour less**: Insulating material should not possess 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.**	4 Marks for any 4 properties

5		**Attempt any FOUR of the following**	
	a)	Working of centrifugal compressor : When the air passes through the rotating impeller it experiences force or work which is performed by centrifugal forces. The work input takes place as an increase in pressure and velocity or speed of the air flow through the impeller. The air flow looses it's velocity after entering in the diffuser section. The diffuser is actually a fixed or static component that escorts the air flow when it leaves the impeller. This loss in velocity eventually results in an additional increase of pressure. The impeller and the diffuser contributes about 65% and 35% of the total pressure developed or produced in the compressor.	2 Marks

			2 Marks
	b)	Working of evaporative type condenser: Evaporative condensers combine the features of a cooling tower and water-cooled condenser in a single unit. In evaporative condensers, both air and water are used to extract heat from the condensing refrigerant. In these condensers, the water is sprayed from top part on a bank of tubes carrying the refrigerant and air is induced upwards. There is a thin water film around the condenser tubes from which evaporative cooling takes place. The heat transfer coefficient for evaporative cooling is very large. Hence, the refrigeration system can be operated at low condensing temperatures (about 11 to13 K above the wet bulb temperature of air). The water spray countercurrent to the airflow acts as cooling tower. The role of air is primarily to increase the rate of evaporation of water.  (c)	2 Marks 2 Marks

	c)	Classify chiller and it application:  OR There are three different types of chillers: (1) air (2) water (3) evaporative condensed chiller Industrial chillers: (1) reciprocating, (2) centrifugal, (3) screw driven (4) absorption chillers. **Application:** **Large buildings** with cooling loads in excess of 400 tons of refrigeration or 1,400 kW typically use water cooled chillers with either centrifugal compressors or Turbocor compressors within the central plant cooling system. **Medium sized buildings** with a cooling load of around 200 – 400 tons of refrigeration or 700 – 1,400 kW will typically use screw compressors or Turbocor compressors. **Small building** with cooling loads under 200 tons or 700 kW will typically use scroll compressors or Turbocor compressors. **Absorption chillers** should only be used where there is an abundance of high quality waste heat or cheap heat. They are often found in hospitals and buildings with heated swimming pools.	2 Marks 2 Marks
	d)	Working of domestic refrigerator : Domestic Refrigerator : The internal parts of the refrigerator are ones that carry out actual working of the refrigerator. Some of the internal parts are located at the back of the refrigerator, and some inside the main compartment of the refrigerator. 1) Refrigerant: The working substance used to make refrigeration is called the refrigerant. The refrigerant run through all the inner parts of the refrigerator. It is the refrigerant that carries out the	2 Marks

cooling effect in the evaporator. It absorbs the heat from the body to be cooled in the evaporator (chillier or freezer) and throws it to the atmosphere via condenser. The refrigerant keeps on recalculating through all the inner parts of the refrigerator in cycle.

2) Compressor: The compressor is to be found at the rear of the refrigerator and in the bottom area. The compressor sucks the refrigerant from the evaporator and discharges it at high pressure and temperature. The compressor is driven by the electric motor and it is the major power intense devise of the refrigerator. In most of the refrigerator reciprocating and hermitically sealed compressor are used.

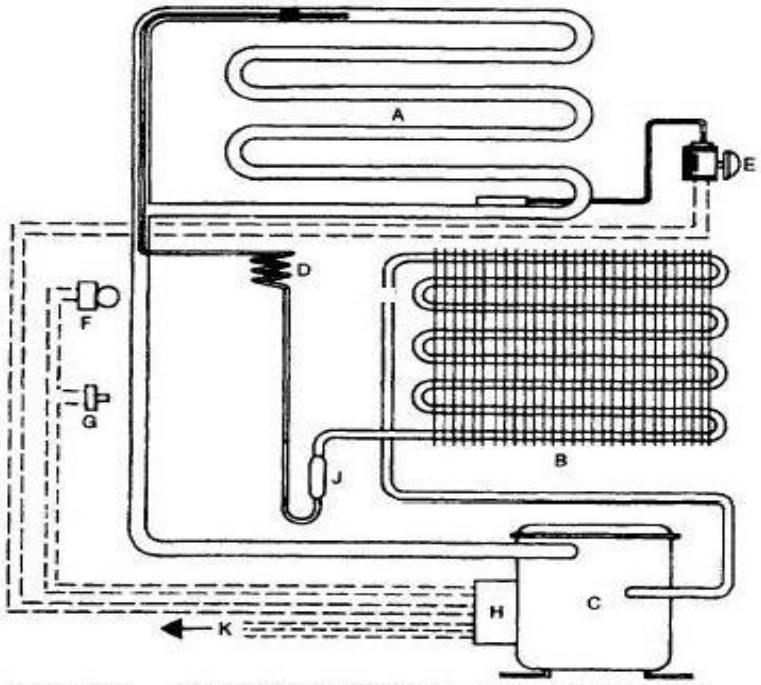
3) Condenser: In refrigerator air-cooled condenser is used since, the constriction of aircooled condenser is very simple. The condenser is the thin coil of copper tubing situated at the back of the refrigerator. The refrigerant from the compressor come in the condenser where it is cooled by the atmospheric air thus losing heat absorbed by it in the evaporator and the compressor. To increase the heat transfer rate of the condenser, it is finned externally.

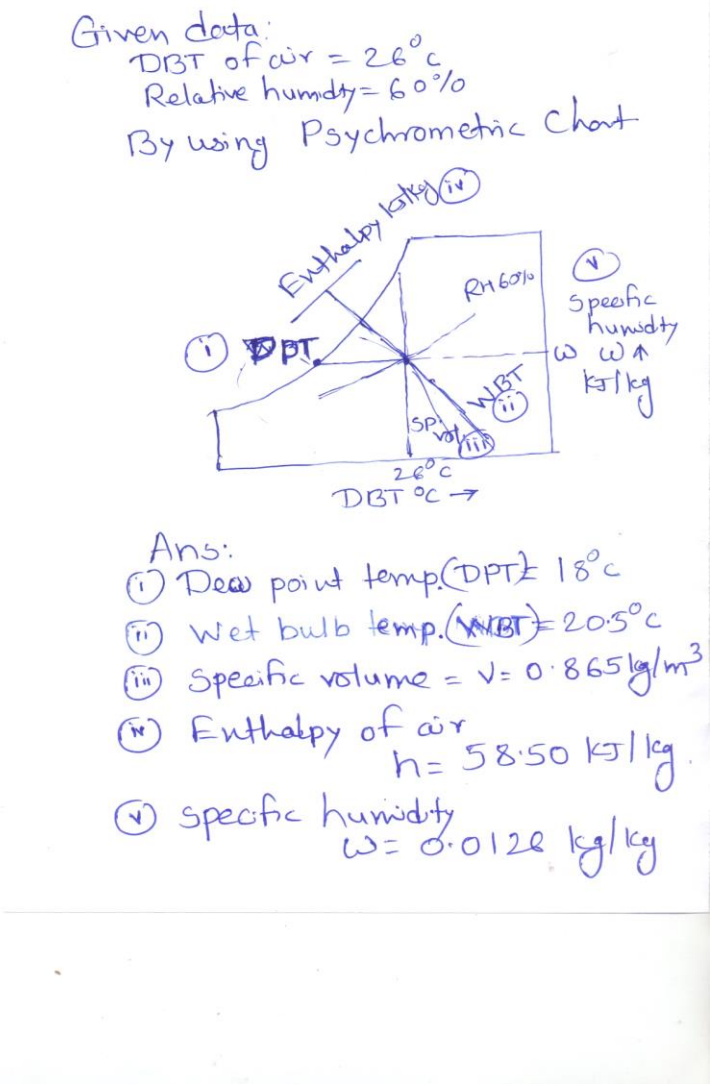
4) Expansion valve or the capillary: The refrigerant leave-taking the condenser enters the expansion devise, which is the capillary tube in case of the household refrigerators. The capillary is the thin copper tubing made up of number of turns of the copper coil. When the refrigerant is passed through the capillary its pressure and temperature drops down suddenly. And it is a constant enthalpy process.

5) Evaporator or freezer: The refrigerant at very low pressure and temperature enters the evaporator or the freezer. The evaporator is the heat exchanger made up of several turns of copper or aluminium tubing. In domestic refrigerators the plate types of evaporator is used as shown in the figure above. The refrigerant absorbs the heat from the substance to be cooled in the evaporator, gets evaporated and it then sucked by the compressor. This cycle keeps on repeating.

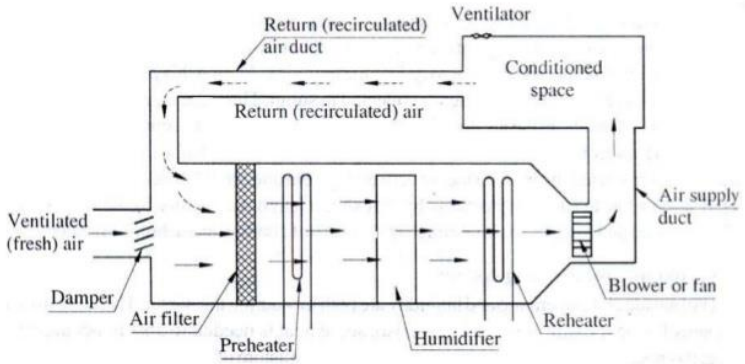
6) Temperature control devise or thermostat: To control the temperature inside the refrigerator there is thermostat, whose sensor is connected to the evaporator. The thermostat setting can be done by the round knob inside the refrigerator compartment. temperature is reached inside the refrigerator the thermostat stops the electric supply to the compressor and compressor stops and when the temperature falls below certain level it restarts the supply to the compressor.

7) Defrost system: The defrost system of the refrigerator helps removing the excess ice from the surface of the evaporator. The defrost system can be operated manually by the thermostat button or there is automatic system comprising of the electric heater and the timer.

		 A evaporator E thermostat and cold control H compressor control box B condenser F interior light J filter drier C compressor G door switch K mains electrical supply D capillary *Domestic refrigerator details*	2 Marks
	e)	i) air conditioner: R22, R134a ii) domestic refrigerator: R134a iii)Ice Plant: Ammonia NH_3 iv) Water cooler:R 22, R134a	1 Mark 1 Mark 1 Mark 1 Mark
	f)	Industrial application of refrigeration: (Any one explanations required) • Air-conditioning for comfort of workers • For textile industries for production of quality textile products. • For manufacturing process in photographic industry. • In printing industries for quality printing. • In paper industries for production of paper • For preservation of food in food industries. Industrial application of air conditioning: (Any one explanations required) • Photographic Industry Provides accurate control of temperature, humidity for manufacturing as well as processing in photographic films. • 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. • Printing Industry Specific temperature and humidity is maintained in printing industry. Paper	2 Marks

		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. • 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.	2 Marks
6		**Attempt any TWO of the following**	
	a)	Psychrometric chart  	3 Marks (For chart) 1 Mark 1 Mark 1 Mark 1 Mark 1 Mark
	b)	• 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. **Sensible heat gain**. When there is a direct addition of heat to the enclosed space, a gain in the sensible heat is said to occur. This sensible heat is to be removed during the process of summer air	1 Mark 1 Mark

		conditioning. The sensible heat gain may occur due to any one or all of the following sources of heat transfer: (a) The heat flowing into the building by conduction through exterior walls, floors, ceilings, doors and windows due to the temperature difference on their two sides. (b) The heat received from solar radiation. It consists of (i) The heat transmitted directly through glass of windows, ventilators or doors, and (ii) The heat absorbed by walls and roofs exposed to solar radiation and later on transferred to the room by conduction. (c) The heat conducted through interior partition from rooms in the same building which are not conditioned. (d) The heat given off by lights, motors, machinery, cooking operations, industrial processes etc. (e) The heat liberated by the occupants. (f) The heat carried by the outside air which leaks in (infiltrating air) through the cracks in doors, windows, and through their frequent openings. (g) The heat gain through the walls of ducts carrying conditioned air through unconditioned space in the building (h) The heat gain from the fan work. **Latent heat gain.** When there is an addition of water vapour to the air of enclosed space, a gain in latent heat is said to occur. This latent heat is to be removed during the process of summer airconditioning. The latent heat gain may occur due to any one or all of the following sources: (a) The heat gain due to moisture in the outside air entering by infiltration. (b) The heat gain due to condensation of moisture from occupants. (c) The heat gain due to condensation of moisture from any process such as cooking foods which takes place within the conditioned space. (d) The heat gain due to moisture passing directly into the conditioned space through permeable walls or partitions from the outside or from adjoining regions where the water vapour pressure is higher. The total heat load to be removed by the air-conditioning and refrigeration equipment is the sum of sensible and latent heat loads of a large restaurant for air conditioning.	3 Marks (Any three points) 3 Marks (Any three points)

	c)	**Winter air conditioning system:**  *Fig. Winter air conditioning system* 16 In winter air conditioning, the air is heated which is generally followed by humidification. The schematic arrangement of the system is shown in Fig. The outside air flows through a damper and mixes up with the re-circulated air (which is obtained from the conditioned space). The mixed air passes through a filter to remove dirt, dust and other impurities. The air now passes through a preheat coil in order to prevent the possible freezing of water and to control the evaporation of water in the humidifier. After that, the air is made to pass through a reheat coil to bring the air to the designed dry bulb temperature. Now, the conditioned air is supplied to the conditioned space by a fan. From the conditioned space, a part of the used air is exhausted to the atmosphere by the exhaust fans or ventilators. The remaining part of the used air (Known as re-circulated air) is again conditioned as shown in Fig. The outside air is sucked and made to mix with re-circulated air, in order to make up for the loss of conditioned (or used) air through exhaust fans or ventilation from the conditioned space.	04 Marks 04 Marks