**1. Define refrigeration:**
ANS: It is a process of creating and maintaining lower temperatures as compared to the surrounding temperature to cool a room, to produce lower temp in a frig.

**2. What is air conditioning?**
ANS: It is a process of controlling **simultaneously** temperature, humidity, purity and velocity of air.

**3. What is Cryogenics?**
ANS: It is a science which deals with creating and maintaining temperatures lower than $-150^0$C.

**4. Write a few applications of refrigeration.**
ANS. Water cooler, Refrigerator, air conditioner, deep freezer, cold storage plant, ice plant, display cabinet, split air conditioner, Packaged unit, Central A.C.Plant.

5. **List a few applications of air conditioning**:
ANS: Window air conditioner, air conditioning of cinema halls, air conditioning of libraries, air conditioning of computer centers, air conditioning of hotels, hospitals, air conditioning of cars, buses, trains and aircrafts and air-ports.

6. **List a few applications of cryogenics:**
ANS: achieving superconductivity in metals, better understanding of molecules movements and thermodynamic concepts, preservation of bull semen for better creed, liquefaction of air, oxygen, nitrogen, hydrogen and helium, obtaining very high vacuum with cryo-pumps.

**7. What is Unit of Refrigeration?**
ANS: like length is measured in meters, the refrigeration is measured in tons of refrigeration (TR). **1 TR means removal of heat at the rate of 211 kJ/min.**
This value of 211 has been achieved as follows:
To convert 2000 pounds (1 short ton) of water at $32^0$F ($0^0$C) into ice at $32^0$F ($0^0$C) in 24 hours, heat is to be removed from water. 144 BTU of heat is to removed from water to convert 1 pound of water into 1 pound of ice. Heat to be removed from 2000 pounds in 24 hours will be= 2000 x 144. Heat removed per minute will be = 2000 x 144 / (24 x 60) =200 BTU/min=211kJ/min
(Because 3025 kcal= 12000 BTU & I kcal=4.18 KJ i.e. **1 BTU=1.055 kJ)**

**8. What is meant by the term refrigerating effect OR cooling effect?**
ANS. It is represented by 'N '. It can be expressed as kJ/kg OR kJ/min.
It is heat removed from the products to be cooled per kg or heat removed per minute.

**9. What is meant by work input to a refrigerating unit?**
ANS: It is represented by 'W'. It is work required in the compressor for I kg of refrigerant i.e. kJ/kg
**OR** It is work input per minute i.e. kJ/min.

**10. What is meant by COP (Coefficient of Performance)?**
ANS: COP= N/W where N is cooling effect and W is work input.

**11. Differentiate between efficiency of a heat engine, COP of a refrigerator and COP of a Heat Pump.**
ANS: η of a heat engine =output/input= (heat supplied – heat rejected)/ heat supplied. It is less than 1.
**COP of a refrigerator = N/W. It is normally much greater than 1 for VCRS.**
**COP of a heat pump = (N+ W)/W. It is still far greater than 1= $COP_{refrigerator}$ + 1**

**12. Give the relation between the COP of a refrigerator and COP of a heat pump.**
ANS: **$COP_{heat\ pump}$ = $COP_{refrigerator}$ + 1**

**13. What is a refrigeration Cycle?**

ANS: .Refrigeration Cycle: A refrigeration cycle consists of the following closed circuit in this very sequence i.e. compressor, condenser, expansion valve, evaporator. (Evaporator placed inside the room to absorb heat. Condenser placed outside the room to reject heat absorbed in evaporator and heat of work input to compressor.) i.e.

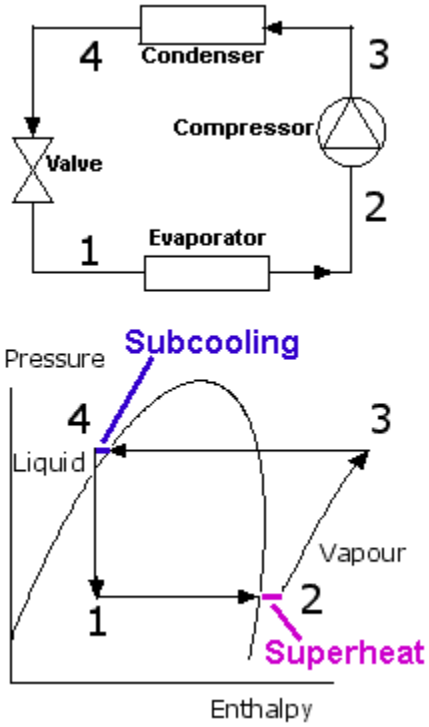



Fig. A Simple Practical Cycle

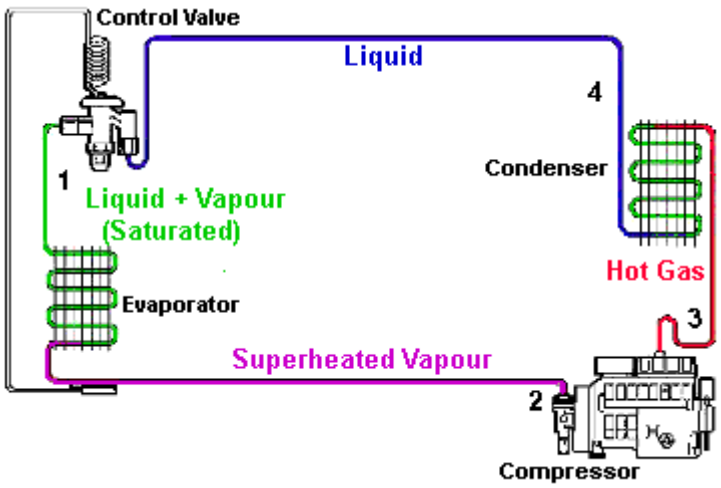



Fig. **The various parts of a Vapour compression cycle**

- Compressor “compresses” the refrigerant in gas form, pressure and temperature rises
- Condenser cools the gas and condenses into liquid form.
- Liquid is expanded through an expansion valve to give a mixture of liquid and Vapour.
- Liquid form then vaporizes (causing cooling) in evaporator.
- Gas form of refrigerant “sucked” back into compressor and the process is repeated again.

**14. What is meant by heat pump?**
ANS: Heat pump is a Refrigeration device to heat the room in winter by employing reversed refrigeration cycle i.e. condenser being placed inside the room and the evaporator being placed outside the room.

**15. What is superheat?**
ANS: temperature above the boiling point at a certain pressure.
For example: NBP of R-22 is $-41^0$C at 1 atmosphere. Say in the vapour form it is at a temperature of $-30^0$C at 1 atm, then it is superheated by $11^0$C i.e. degree of superheat is $11^0$C. Degree of **SUPERHEAT IS IN VAPOUR FORM.**

**16. What is meant by sub-cooling or degree of sub-cooling?**
ANS: Fall of temperature in **LIQUID FORM** from the boiling point at a certain pressure.
For example: Normal boiling point of R-22 is $-41^0$C at 1 atm. Suppose it is in liquid form at a temperature of $-50^0$C at 1 atm. Then it is a sub-cooled liquid and degree of sub-cooling is $9^0$C.

**17. What is effect of superheat on COP?**
ANS: If the degree of superheat is $< 5^0$C, COP increases. If the degree of superheat is greater than $5^0$C, COP decreases. Due to superheat there is increase in N and W.

**18. What is effect of sub-cooling on COP?**
ANS: Increase of degree of sub-cooling increases the COP as it increases cooling effect without increasing the work input.

**19. Discuss the effect of evaporator pressure on COP?**
ANS: if the evaporator decreases (Lower temperature to be achieved), COP decreases as cooling effect decreases and the work input increases.

**20. What is the effect of condenser pressure on COP?**
ANS: If the condenser pressure increases (it is due to increase of ambient temperature in summer), COP decreases. If the pressure in condenser decreases (in winter), COP increases.

**21. What is meaning of DRY compression**?
ANS: When the refrigerant vapour is dry saturated at the **START of compression. Show it on T-s chart as well as on p-h chart.**

**22. What is meant by WET compression?**
ANS: When the refrigerant vapour is dry saturated vapour at the **END OF COMPRESSION. Show it on T-s as well as on p-h chart.**

**23. What is clearance or clearance volume in a reciprocating compressor?**
ANS: When the piston is moving in the cylinder, it is desirable the piston does not strike the cylinder head cover. To achieve this there is a small space between the cylinder head and the extreme position of piston. The volume of this space is called clearance volume or clearance.

**24. Difference between Heat engine and Heat pump.**
ANS: Heat Engine converts heat energy into motion or Mechanical energy Like Internal combustion engine in a scoter, car, bus etc.
Heat Pump: It is a device which converts mechanical energy into heat. It is a device to heat the room in winter with comfortable conditions. It is a winter air conditioner.

**25. Compare open cycle and closed cycle Refrigeration system.**
ANS: OPEN CYCLE: It relates the refrigeration cycle in an aircraft where the primary refrigerant is air. The conditioned air is open to the cabin i.e. cooled air comes in physical contact with the passengers.i.e. air Refrigeration cycle is an open cycle.
CLOSED CYCLE: when the conditioned air does not come in contact with the passangers rather there is a heat exchanger in the cabin of the aircraft. Cabin air gets cooled by coming in external contact with the cooling coil and goes into the cabin. In this case working pressures are high but air does not pick up moisture from the cabin as is the case in open air cycle.

**26. What is the effect of sub cooling and superheating on Refrigeration work?**
ANS: Sub-cooling does not change the work input but increases the refrigerating effect and hence increases the COP
Superheating: if the degree of superheat is less $5^0$C, increase in refrigerating effect is more than the increase in work input and thus COP increases. But if the degree of superheat is greater than $5^0$C, then the increase in work input is more than the increase in refrigerating effect and the COP decreases.

**27. Draw the sketch of Electrolux Refrigeration system.**

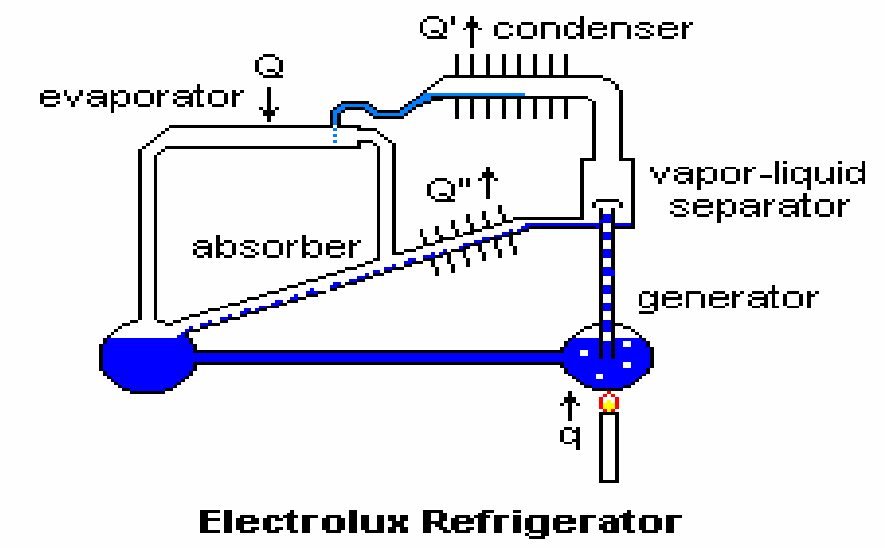



Fig. Line Diagram of Electrolux Domestic Refrigerator

**Absorption System:**
**. Ammonia gas bubbles & mixes with water in the generator**
**➢ Ammonia/water mix flows through pipes to the bottom of the separator.**
**. Ammonia vapors travels to condenser & cools (condenses)**
**. Weak ammonia solution from separator goes to absorber.**
**➢ Liquid $NH_3$ travels to the evaporator**
**➢ Hydrogen in evaporator causes ammonia to evaporate (heat removed)**
**➢ Hydrogen/Ammonia mix goes to absorber, where ammonia is absorbed & hydrogen returns to evaporator**
**➢ Ammonia solution returns to generator and process starts again.**

**28. Write applications of steam jet Refrigeration and mention its limitations.**
ANS: APPLICATIONS: It can be used in the industries where waste steam is available from a process namely in a paper industry, in a leather industry, in a brewery etc.
LIMITATION: Needs boilers to produce steam and thus is likely to become a costly affair.

**29. Define RSHF and Bypass factor.**

(i) RSHF = RSHL / (RSHL+RLHL) and is always less than 1.
RSHL is room sensible heat load contributed due to temperature differences only
RLHL is room latent heat load is contributed due to change of humidity content

(ii) Bypass factor = BPF = $(t_2 - t_3) / (t_1 - t_3)$, (refer fig.)

$(t_2 - t_3)$ is the temperature drop which could **NOT** be achieved i.e. air is by passed.
$(t_1 - t_3)$ is the temperature drop which could have been achieved. REFER FIG.

**30. Differentiate between split A.C system and window A.C system.**
ANS. **Split A.C. System**: evaporator cabinet can be placed anywhere in the room to be air conditioned, Condensing unit is placed outside the room or outside the house at a convenient location. Lengths of tubes, number of joints and number of bends carrying the refrigerants are increased and the chances of leakage are more. The pressure drop will increase and hence the running charges will increase. But there are no changes in the room or in the window as in a window air conditioner.

**Window A.C. System**: The air conditioner is fitted in the window such that the cooling coil is towards the inside of the room and condensing unit is towards outside of the room. Hence there are changes in the window. Hot air from the condenser will available in the corridor which is not liked. But the operating and installation charges will be less in the case of window air conditioner as compared to the split A.C. system.

**31. Differentiate between Ventilation load and Infiltration load**.
ANS: Ventilation load: heat load added to the room (in turn added to AC) due to fresh air brought in the room to maintain the oxygen content in the room air.
Infiltration Load: Heat load added to the room (in turn to AC Plant) due to the frequently opening and closing of door of the air conditioned room.

**32. Write the advantages of cooling towers used in Refrigeration Industry**.
ANS: the advantages of cooling tower are significant reduction in the cost of water used in the condenser.
The cooling tower is normally placed at the roof of the building thus it does not need any extra space.

33. **Define the term COP of a refrigeration system. What are factors affecting COP of a refrigeration system?**
ANS: COP= N/ W, N=cooling effect/kg, W= work input/kg, COP of a refrigeration of a vapour compression system is > 1.
Factors affecting COP: (i) degree of superheat, (ii) degree of sub-cooling, (iii) evaporator pressure, (iv) condenser pressure, (v) temperature to be achieved

**34. Enumerate the desirable properties of refrigerants commonly employed in refrigeration and air conditioning applications.**
ANS: Desirable properties of a refrigerant: Lower boiling point, lower freezing point, lesser specific volume, high latent heat, less work input/kg of refrigerant, high COP, minimum running charges, non-toxic, non- inflammable, inert, non-decomposable, less leaking tendency, easily detectable leakage, cheap, easily available in abundance and everywhere, chemically inert with the material of

construction, materials being cooled and the lubricant, less viscosity, high specific heat and high thermal conductivity.

35. **Explain the effect of sub-cooling on the performance of Vapour compression refrigeration system.**
ANS: Increase of sub-cooling increases the cooling effect without changing the work input. Hence COP increases with the increase of degree of sub-cooling.

**36. Differentiate between an air conditioner working on reverse cycle in winter to produce heating effect and an air conditioner employing an electric heating filament to produce required heating effect. Which air conditioner will you prefer and why?**

ANS: Air conditioner working on reverse cycle will have higher COP than when it was being used for cooling in summer. Hence running charges will be reduced. Heating provided will be much greater than the electricity consumed i.e. heating effect will be more in air conditioner working on reverse cycle than directly electrically heated. Hence air conditioner working on reverse cycle must be preferred.

**37. Enumerate five distinctions between the vapour compression and vapour absorption refrigeration system.**
ANS: Distinctions:
(i) For lower tonnage capacity vapour absorption system is more expansive.
(ii) For 50 TR cost becomes the same for the two systems. For TR > 50 tons the vapour system becomes more favorable as it becomes cheap.
(iii) Vapour absorption systems are environmentally friendly as there is no GWP and no ODP.
(iv) A single unit of 7000 tons capacity is available in VAS where as much less capacity say, 1000 TR single units in VCS.
(v) In VAS, liquid coming from the evaporator has no bad effect whereas in VCS the liquid going to compressor will result in physical breakdown of the compressor.
(vi) In the event of lower temperature requirement in VCS the cooling capacity decreases very significantly whereas in VAS the cooling capacity can still be same only by controlling the heating rate in the generator.
(vii) Compressor of compression system is replaced by an absorber, pump, heat exchanger, generator, analyser, rectifier and another expansion valve.

**38. Enumerate the characteristics requirements of refrigerant, absorber and mixture in vapour absorption refrigeration systems.**
ANS (i) The absorbent should have high affinity for the refrigerant at the evaporator conditions and least affinity at generator conditions.
(ii)The absorbent and the refrigerant mixture should form an ideal liquid mixture.
(iii) The boiling points of absorbent and refrigerant should be very far apart say $>100^0$C as in case of ammonia and water.

**39. What are the modifications required for an existing R-12 refrigeration system to be retrofitted to R-134a refrigerant?**
ANS: (i) The lubricant has to be changed.
(ii) The R-134a should be totally free of moisture.
(iii) The condenser and evaporator are to be redesigned.

**40. Differentiate between specific humidity and relative humidity.**
ANS: Specific humidity is the amount of water vapors per kg of dry air i.e. 10 g of water vapours per kg of dry air.
Relative humidity: Ratio of mass of water vapors /$m^3$ of dry air to mass of water vapous /$m^3$ of saturated air at the given dry bulb temperature. It is expressed as %RH.

**41. Differentiate between working of window and split air conditioners.**
ANS: There is a difference in the layout first. In window air conditioner it is placed in the middle of the window with evaporator inside the room and the condensing unit facing outside the room. In case of split air conditioner the evaporator is placed inside the anywhere and the condensing unit is placed outside the room at a convenient location. The pressure drop is more in split unit and hence running charges are more. The chances of leakage are more since the refrigerant pipe lines are of much greater length in the split units.

**42. Why is aircraft needs air conditioning?**
ANS: Air craft is airtight and heat is being added to the aircraft inside from the various sources like occupants, lights and equipments, foods, solar radiations etc. and hence needs air-conditioning to make the passengers comfortable.

**43. What is Bell Coleman Cycle or Reversed Brayton Cycle or Reversed Joule Cycle or Gas Refrigeration Cycle?**
AND: It is a cycle which consists of two isentropic processes and two isobaric processes. Since in this cycle the working substance is air (OR gas) work of expansion is recovered in a turbine and hence net work is considered while finding COP of the unit i.e. COP = N/Net work input

**46. What do you understand by the term cascading in refrigeration systems**?
ANS- Cascading means 2 or 3 independent vapour compression systems with condenser of first system forming a heat exchanger with the evaporator of system2.
Similarly, condenser of system2 forms a heat exchanger with evaporator of system 3 and so on. The lowest temperature which we can achieved by cascade refrigeration is -100 $^0$C. Ref to Fig.

**47. What are various types of drying agents and antifreeze solutions commonly employed in refrigeration and air conditioning systems?**
ANS- a) various types of drying agents: 1. Silica Gel, 2.Calcium chloride.
b) Various anti-freeze solutions: 1. Sodium chloride solution 2. Calcium chloride solution
3. Glycerin solution

**48. Enumerate the alternative refrigerants proposed for the R-12 and R-22 refrigerants.**
**ANS- Replacement of R-12 is R-134a**
Replacement of R-22 is R-22.

**49. What do you understand by adiabatic saturation temperature?**
ANS- Adding moisture at **constant enthalpy** till the air becomes saturated i.e. no more moisture addition possible after saturation. The temperature thus achieved is adiabatic saturation temperature or wet bulb temperature.

**50. Differentiate between working of package and central air conditioning systems**.
**ANS- Package Air Conditioner**: It is a factory assembled unit with cooling capacity of 10tons. Condenser in these units is water cooled. It is suitable for 2-3 rooms or a single medium hall.

**Central Air Conditioning Plant:** It is assembled at the site. It is suitable for a multistory building/ hospital/ hotel. In this water is chilled with the main refrigeration unit which is placed at the basement of the building. This chilled water through centrifugal pump is sent to various rooms to be air conditioned. Each room has fan coil unit (FCU) which contains chilled water. A fan throws air over this fan coil unit and conditioned air goes into the room and re-circulates as usual. Single Central air conditioning plant may have cooling capacity 100 to 1000 tons.

**51. a) List the limitations of reversed Carnot cycle?**
**ANS- Limitations:** It contains isentropic process then isothermal, isentropic and isothermal. Isentropic process has to be very fast. Isothermal process has to be very very slow. Therefore, this combination of fast -slow followed by fast -slow has not been achieved till date.

**52. What is change in COP of a refrigeration and power consumption if we lower the refrigeration temperature?**
ANS- By lowering refrigeration temperature, N= cooling effect per Kg is reduced and the W= work input per Kg is increased. COP = N/W. Therefore COP decreases.

**53. Draw the line diagram of actual vapour absorption refrigeration system?**

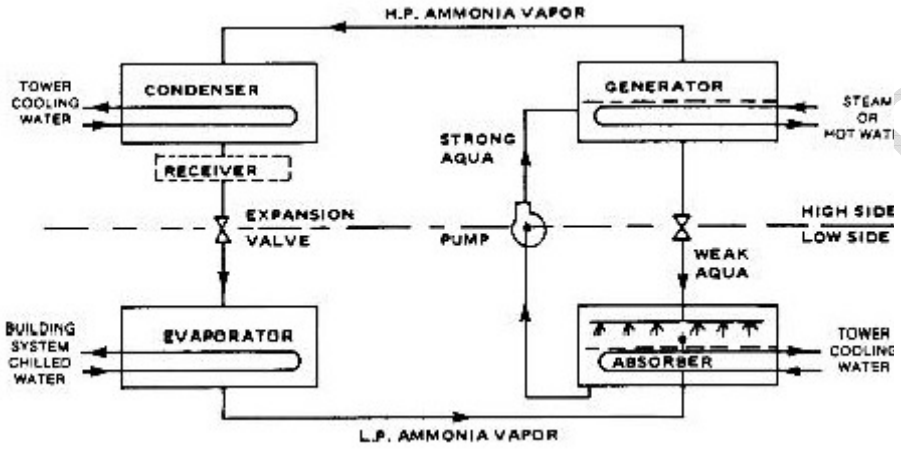



Fig. Line diagram of actual vapour absorption (ammonia) refrigeration system

**54. Explain the concept of flash inter cooling.**
ANS- **To reduce work input into the compressor**, refrigerant should be dry saturated at the start of compression. To achieve this in multi-compressor system we employ a chamber containing liquid vapour refrigerant which ensures that only dry saturated vapour goes to the next compressor and the superheated vapour coming from the previous compressor becomes dry saturated. In a 3 stage compression system there will be two flash chambers, one before the second compressor and 2nd before the 3rd compressor.

**55. Define Degree of saturation?**
ANS: It is a ratio of $w/w_s$ i.e. ratio of specific humidity to saturated humidity. It has no units. It is always less than 1.

**56. Explain the various kinds of fan arrangements?**
ANS: Centrifugal fan, axial flow fan, and mixed flow fan.

**57. Explain the physical significance of By Pass Factor with reference to heating and cooling coils.**
ANS: Cooling coils: air does to cool to required coil temperature as some air do not come in physical contact with the coil and is said to be by passed. It $t_1$ is air temperature entering the cooling coil. $t_3$ is the outgoing temperature of air. $t_2$ is the cooling coil temperature. Temperature drop which is achieved is $t_1 - t_3$. Temperature drop which was possible $t_1 - t_2$. Hence by pass factor for cooling coil is $( t_2 - t_3/(t_1 - t_2)$ and it is always less than 1.

Heating coil: air does not heat to required coil temperature as some air do not come in physical contact with the coil and is said to be by passed. It $t_1$ is air temperature of air entering the heating coil. $t_3$ is the outgoing temperature of air. $t_2$ is the heating coil temperature. Temperature rise which is achieved is $t_3 - t_1$. Temperature rise which was possible $t_2 - t_1$. Hence by pass factor for heating coil is $( t_2 - t_3/(t_2 - t_1)$ and it is always less than 1.

**58. Explain the Joule Thomson effect.**
ANS: It means expansion at constant enthalpy i.e. throttling process. Three possibilities are possible in Joule Thomson Effect.

(i) Heating after expansion if temperature before expansion is higher than inversion temperature.
(ii) No heating or no cooling if the temperature before expansion is inversion temperature itself.
(iii) Cooling after expansion if the temperature before expansion is lower than the inversion temperature.

Mathematically $\mu = (t_1 - t_2)/ (p_1 - p_2)$ which can be - for heating, can be 0 for no heating or no cooling and will be + value for cooling effect.

**59. Write the name of the refrigerant to be used in ice plants.**
ANS: AMMONIA ( $NH_3$ )

**60. Why cannot air be used in refrigeration?**
ANS: It is because phase change of air is not possible since its normal boiling point is $--191^0$C. Its COP is very less. Its running charges are high.

**61. Where do we require multi-stage compression refrigeration?**
ANS: In a refrigeration system there are two temperatures. One is the application temperature and the other is the ambient temperature. When it is required to achieve low temperature (for example - $60^0$C), two stage compression will be a basic necessity. If it is required to achieve a temperature of $-100^0$C, a three stage compression will be required.

**62. Why water inter cooling cannot be used in multistage compression refrigeration?**
ANS: Temperature after the compressor is much less than that of water temperature and hence water inter cooling is not possible in refrigeration systems.

**63. What is Sensible Heat Load? Give examples.**
ANS: Sensible heat load is due to temperature difference only. It has no connection with the water Vapour in the air. Therefore it is also called DRY LOAD.
Examples:

- Solar heat gains through walls, roof and floor
- Solar heat gains through glass
- Sensible heat gain from occupants
- Sensible heat gains from light
- Sensible heat gain from power equipments
- Sensible heat gain from Products (Potatoes, Bananas, apples etc.)
- Sensible heat gain from infiltrated air
- Sensible heat gains from additional infiltrated air
- Sensible heat gains from ventilation air
- Sensible heat gains through supply duct
- Sensible heat gains through return duct
- Sensible heat gains through miscellaneous sources

**64. What is latent heat load? Give examples.**
A: Latent heat load only due to moisture difference.
Examples: Latent heal from occupants
Latent heat load from infiltrated air
Latent heat gains from additional infiltrated air
Latent heat gains from ventilation air
Latent heat gains from miscellaneous sources

**65. Define RSHF, ERSHF, and GSHF.**

ANS: RSHF=RSHL/ (RSHL+ RLHL)
ERSHF= ERSHL/ (ERSHL+ERLHL)
GSHF = GSHL/ (GSHL+GLHL)

**67. What are comfortable conditions?**

ANS: The different combinations of temperature and humidity which give the same degree of comfort are 22 to 27 $^0$C with RH 35 % to 65%.

**68. What is meant by comfort zone?**

ANS: It is an area on the psychometric chart
bounded by comfortable conditions of 22-27$^0$C with RH 35 % to 65 %.

69. **How was HFC-134a selected as a replacement refrigerant for CFC-12 in automobile air-conditioning systems?**

ANS: Engineers for automotive manufacturers conducted research and testing on many potential substitutes for CFC-12 before selecting HFC-134a. As part of this research and testing, they reviewed the potential health effects, toxicity, flammability, and corrosivity of each potential substitute, evaluated the effect of each compound on the life and performance of the air-conditioning components in the various models made by each manufacturer, and investigated the effect of each compound on the system's cooling capacity. They determined that HFC-134a was the most suitable alternative.

**70. It is known that the old refrigerant, CFC-12, does not pose cancer risks when used properly. Is this also true of HFC-134a?**

ANS: HFC-134a is regarded as one of the safest refrigerants yet introduced, based on current toxicity data. The chemical industry's Program for Alternative Fluorocarbon Toxicity Testing (PAFT) tested HFC-134a in a full battery of laboratory animal toxicity studies. The results indicate that HFC-134a does not pose a cancer or birth defects hazard.

**71. Is HFC-134a flammable?**

ANS: HFC-134a is considered as safe as or safer than CFC-12 in motor vehicle uses, including in collisions. Like CFC-12, HFC-134a is not flammable at ambient temperature and atmospheric pressures. However, HFC-134a service equipment and vehicle A/C systems should not be pressure tested or leak tested with compressed air. Some mixtures of air and HFC-134a have been shown to be combustible at elevated pressures. These mixtures may be potentially dangerous, causing injury or property damage.

72. **What is EPA?**

ANS: Environment Protection Agency. It takes care of all the problems of environment and their overall effect and suggests the remedial measures for the environment protection.

**73. Differentiate between Ventilation load and Infiltration load.**

ANS: Ventilation Load: It is a heat load on the air conditioning plant due to **fresh outside air** purposely introduced into the room. In the absence of any specific information it can be assumed as 12 air changes per hour.
Infiltration Load: It is also a heat load due to **outside air** but it is due to outside air going in due to frequent use of door opening while going in or coming out of the air-conditioned room.

74. **Write the advantages of cooling towers used in refrigeration industry.**
ANS: Cooling towers are used to re-circulate condenser water time and again to reduce the cost of water used in condenser. The advantages of cooling tower in refrigeration industry are (i) space requirements are very less, (ii) Cost of water is **very significantly** reduced had the fresh water was used in the condenser.

**75. List the various types of compressors used in refrigeration.**
ANS: (i) Reciprocating compressor
(ii) Rotary compressor
(iii)Centrifugal compressor

**76. Indicate where which type of compressor is used?**
ANS (a) Reciprocating Compressor: (i) Where the NBP of refrigerant is lower than the application temperature
(ii) Where evaporator and condenser pressure are positive pressures and the difference in these is greater than 3.5 atm.
(iv) Where the volume of refrigerant vapour at entry to compressor is less.
For example: such conditions are satisfied in case the refrigerant is R-22, $NH_3$, $Co_2$, R-134a, air
(b) Rotary compressor (i) Where the NBP is near to the application temperature.
(ii) Where evaporator pressure is higher than atmospheric pressure but close to it.
(iii) Where pressure difference between condenser and evaporator pressure is > 1.5 atm but < 3.5 atm
Such condition is found with ISOBUTANE as refrigerant.
© Centrifugal compressors: (i) Where the NBP is much higher than the application temperature.
(ii) Where the pressure in evaporator is vacuum.
(iii) The volume to be handled at the inlet of the compressor is extremely large.
(iv) Where the pressure difference between evaporator pressure and condenser pressure is < 1.5 bars.
EXAMLE: R-11 and R-114
75. List the various types of condensers with their practical applications.
ANS: Various types of condensers are Air Cooled, Water Cooled and Evaporative Cooled
**Air Cooled Condensers**: Natural air cooled as in domestic refrigerators
Forced air cooled Condensers as are used in water coolers, window air conditioners, big size refrigerators, display cabinets, deep freezers, air conditioning of vehicles.
**Water Cooled Condensers**: used in packed units, Used in air conditioning plants of libraries, cinema halls, hotels, computer centers, hospitals
**Evaporative Cooled Condensers**: Used in big industrial units like ice plants, cold storages, breweries, milk plants, refineries etc.

**76. List the various types of expansion devices with their practical applications.**
ANS: Various types of expansion devices:
(i) Capillary Tube: very small diameter tube with no moving parts thus extremely simple and least expensive: Used in refrigerators, window air conditioners, water coolers, display cabinets, deep freezers etc.
(ii) A.E.V. i.e. Automatic Expansion Valve: Used in plants where cooling load is almost constant like in ice plants. These expansion valves are not suitable where cooling loads vary because these increase the flow when the heat load on the evaporator decreases and decrease the flow of refrigerant through the evaporator when the heat load on the evaporator increases and hence contradictory.
(iii) T.E.V. i.e. Thermostatic Expansion Valve: Used in the largest number of practical applications because they cause the required pressure drop and also maintain a constant degree of superheat at the outlet of the evaporator under all conditions of heat loads on the evaporator i.e. they decrease the flow of refrigerant when the load on the evaporator decreases and vice versa.

(iv) Low Side Float Valve: Used in industrial units as the float valve is located in the evaporator itself. It is cheap and simple.
(v) High Side Float Valve: Used in big industrial units as the float valve is located in the condenser itself. It is also cheap and simple.

**77. List the types of evaporators with their practical applications.**
ANS: Dry expansion type and flooded type evaporators
Dry expansion type: Used in refrigerators, water coolers, window air conditioners, display cabinets, deep freezers, incubators, air conditioning plants of libraries, hotels, hospitals, computer centers etc.
Flooded evaporators: The evaporators are filled with liquid refrigerant to make full use of evaporators for evaporation only. These types of evaporators do need an accumulator to separate vapour from the liquid refrigerant as only vapours can go to compressor. These are used in big refrigeration plants in industries only.

78. **List the various piping materials used in refrigeration plants**.
ANS: Copper and mild steel
Copper: Used in all plants using R-22, R-134a, R-13 and all hydrocarbons and their derivatives as refrigerants.
Mild steel: It is used with only ammonia as refrigerant because copper is highly reactive with copper. Actually copper is better material to use since its thermal conductivity is very high as compared to that of mild steel. But in case of ammonia it is practical necessity to use mild steel.

**79. Discuss leakage of refrigerant.**
ANS: there are two types of leakages. External leakage and internal leakage
External leakage: This leakage takes place when internal pressure is greater than atmospheric pressure which is quiet common. In this leakage, refrigerant goes out to atmosphere. If the leakage is not detectable (with most Freon's) by smell then it is direct loss of money and atmosphere will be effected may be with GWP and ODP.
Internal Leakage: This leakage takes place when working pressures are vacuum inside as is in case of R-11 and R-114. Due this type of leakage atmospheric dust, water and air will enter the system.
**Dust** will decrease the heat transfer in the evaporator and condenser and also will increase the wear and tear of the compressor.
**Water** will form acid or alkali with the refrigerant and will be more corrosive to the materials of construction. It will also effect the lubrication. It will freeze when reaches the expansion valve and choke the system. The unit will be working physically but absolutely no cooling taking place.
**Air** entering the system will increase the working pressures in the evaporator and condenser as it is being non-phase change and thus increase the temperatures there. Work input will increase and required temperatures cannot be achieved. It will also reduce heat transfer in the evaporator and condenser as being poor conductor of heat.

80. **Define dry bulb temperature, wet bulb temperature, dew point temperature.**
ANS: **Dry bulb temperature, $t_{db}$**, It is temperature of a space measured by an ordinary thermometer. It is also called Dry Bulb Temperature.
**Wet Bulb Temperature, $t_{wb}$**, It is temperature read from the stem of a thermometer whose bulb is surrounded by a **constantly wetted wick**. Actually it is temperature of adiabatic saturation temperature of air i.e. air becomes saturated in the vicinity of the thermometer bulb by taking entire heat from the atmosphere under steady state conditions and the thermometer shows a **constant reading**.
**Dew point temperature: Cool the atmospheric air** by removing heat. Its temperature will start decreasing. Ultimately a temperature will be reached when the first drop of water condenses. This temperature is called Dew Point Temperature. It is also a state of saturated air but its heat content has been decreased from the starting point.

**81. Define a psychrometric chart and explain its utility.**

Ans: Psychrometric Chart: It is a chart to study the psychrometric properties (Properties of air containing moisture i.e. properties of moist air) of air. These properties are dry bulb temperature, wet bulb temperature, dew point temperature, relative humidity, enthalpy of air, specific humidity of air, specific volume of air and sensible heat factor (used in the design of air conditioning plants). All temperatures along x-axis of the chart. Specific humidity and SHF along y-axis of the chart. Other properties are found from the chart after locating the condition of air on the chart. This condition of air is located by any two properties given or known.

Utility of the Chart: It helps to decide the processes to be carried on the atmospheric air to reach the comfortable conditions of air.

**82. Mention the equations to determine the psychrometric properties of air.**

ANS: (i) **Partial pressure of water vapour in air**

$$p_v = (p_{vs})_{wbt} - (p_t - (p_{vs})_{wbt})(t_{db} - t_{wb})/(1547 - 1.44\, t_{wb})$$

***$(p_{vs})_{wbt}$= partial pressure of water vapour in air at wet bulb temperature, found from the steam tables against the wet bulb temperature***

***$p_t$ =total atmospheric pressure or barometric pressure***

***$t_{db}$=dry bulb temperature***

***$t_{wb}$= wet bulb temperature***

**(ii) Specific humidity of air** $= \omega = 0.622\, p_v / (p_t - p_v)$

**(iii) Relative Humidity** $= \varphi = p_v / (p_{vs})_{wbt}$

**(iv)Dew point temperature**: Find $p_v$ from the given data. Now consider this $p_v$ as $p_{vs}$ and from the steam tables read temperature corresponding to this $p_v = p_{vs}$. It will be the Dew point temperature.

**(v) Vapour density**

$$p_v \cdot 1 = \rho\, R_{air}\, T_{db}$$

$$\rho = p_v / (287 \times T_{db}) \quad kg/m^3$$

(vii) **Enthalpy of air** $= h = (t_{db} + \omega (2500 + 1.88\, t_{db}))$ kJ/kg

(viii) **mass of air** $m_a = ((p_t - p_v)\, V) / R_{air}\, T_{db}$ kg/min

If V is in $m^3$/ min

**83.Show the various psychrometric processes on the psychrometric chart:**

**84. Explain adiabatic mixing of two sreams.**

ANS: adiabatic mixing means mixing at constant enthalpy i.e. enthalpy of the mixture is the sum of enthalpies of two steams.

Mathematically

$$m_1 h_1 + m_2 h_2 = (m_1 + m_2)\, h_m$$

$$m_1 \omega_1 + m_2 \omega_2 = (m_1 + m_2)\, \omega_m$$

**85. Explain purity of air as regards to air conditioning.**

**ANS: If the following impurities, in the air, are in sizes lower than the values in the table then the air will be considered as pure air.**

Table: Shows the particles, their permissible sizes and their sources

| Particles | Sizes | Source |
|---|---|---|
| Dust | < 100 m | From natural and mechanical processes |
| Smoke | o.1 – 0.3 m | Incomplete combustion |
| Fumes | < 1 m | Condensation of vapour |
| Fog | 2-60 m | Condensation of vapour |
| Mist | 60-200 m | Atomizing and spraying |
| Microbes | 0.003 - .06 m | Virus |
| Bacteria | 0.4 – 5.0 m | Environmental |
| Fungal spores | 10-100 m | Environmental |

**85. What do mean by heat gain from occupants?**

ANS: Inside the air-conditioned space persons work. These persons are called occupants. Our human body is such that it is always loosing heat, partly as sensible heat and partly as latent heat. Sensible heat is due to temperature difference. Latent heat is due to moisture difference. Total heat lost is sum of SH and LH. This heat lost depends on the sex, activity and surrounding conditions. An adult female loses 75 % of an adult male. A child loses 60 % of that of an adult person. In absence of any specific conditions , **one can assume that the heat lost by an adult male person will be 200 kJ/hr as Sensible and 300 kJ/hr as latent heat.** If as in summer, the outside temperature is above the body temperature. The body will not be losing heat by sensible means rather it will be gaining sensible heat from the surroundings. It will become highly uncomfortable unless the total heat is lost as latent heat i.e. by perspiration. In the absence adequate air supply, person will not be able to loose heat and it may lead to fatal health results.

**86. Explain inside design conditions.**

ANS: These refer to for human comfort and industrial processes.

Human Comfort: People made to sit in different halls under different inside conditions and finally combination of temperature, humidity, velocity and purity of air were finalized giving maximum comfort to larger population.

These conditions are

Temperatures 22-27$^0$C

Relative Humidity 35-60%

Velocity of air 8-12 m/min

Purity of air Contaminants are present within permissible sizes

Table shows the particles, their permissible sizes and their sources

| Particles | Sizes | Source |
|---|---|---|
| Dust | < 100 m | From natural and mechanical processes |
| Smoke | o.1 – 0.3 m | Incomplete combustion |
| Fumes | < 1 m | Condensation of vapour |
| Fog | 2-60 m | Condensation of vapour |
| Mist | 60-200 m | Atomizing and spraying |
| Microbes | 0.003 - .06 m | Virus |
| Bacteria | 0.4 – 5.0 m | Environmental |
| Fungal spores | 10-100 m | Environmental |

**Industrial Processes:**

Brewery 5-10$^0$C, 30-50 % RH

Textile industry 24-26$^0$C 50-85 % RH

Drug industry 24-26$^0$C 20-40 % RH

Printing industry 20-30$^0$C 45-80 % RH

**87. Define outside design conditions. Give examples of outside conditions.**

ANS: These are average conditions occurring for most of the summer i.e**. SUMMER OUTSIDE CONDITIONS**. These are different for different places. For example

Chandigarh 40.1$^0$C DBT, 23.9$^0$C WBT, RH 27 %
Delhi 40.4$^0$C DBT, 23.9 $^0$C WBT, RH 26 %
Calcutta 35.3$^0$C DBT, 27.9$^0$C WBT, RH 60 %

**OUTSIDE WINTER DESIGN CONDITIONS**:

| CITY | DBT | WBT | % RH |
|---|---|---|---|
| **Delhi** | **7.2** | **5.0** | **70 %** |
| **Calcutta** | **13.3** | **8.9** | **55%** |

**88. How to protect a refrigeration unit?**

**ANS:**

- **Against low gas levels**: Check for leakage and fill more refrigerant
- **Against voltage fluctuations**: Use a voltage stabilizer
- **Against frequent starts**: Restart after at least 1 minute
- **Against over currents**: use a overload protector
- **Against freezing**: use defrosting heater or timer for automatic defrosting after a fixed interval
- **Against high humidity**: Use a suitable dehumidifier such as Silica gel
- **Year maintenance round** (indoor & outdoor units)

**89. What are safety precautions during installation?**

**ANS: (a) Precautions by the user**

- Exposed live and rotating parts must be covered.
- Unit must be anchored safe & sound
- A good handover to the user is important

**(b) Precautions by the Installer**

.Must has adequate protective clothing

- Must observe all safety procedures (great attention during handling of heavy loads)
- Protection against burnout during brazing
- When putting the unit in place is sure you are in on a safe place
- Provision of an adequate means for the discharge of water
- It is illegal to discharge gases into the air.

**90. What are the materials used in the construction of Air conditioners**

**ANS**: **Plastic**

- Indoor enclosure
- Fan blades
- Electric connection covers
- Remote control unit

**Other materials**

- Lubricating Oil
- Refrigerant
- cup (microprocessor)
- Tubing and insulation

92. **Explain the working of an air conditioner.**

**Ans:** An air conditioner is basically a refrigerator without the insulated box. It uses the evaporation of a refrigerant like Freon to provide cooling. The mechanics of the Freon evaporation cycle are the same in a refrigerator as in an air conditioner. The term Freon is used generically for any type of various nonflammable gases used as refrigerants and as propellants for aerosols. Basically, all the air conditioners work the same way regardless of what Freon you are using. They absorb heat from

inside and then release it outside. Air conditioners rely on the principle that a fluid at low pressure will condense at low temperature but when this fluid is raised to a higher pressure, it will condense at higher temperature. Warm air is drawn from the room through intake vents; warm air comes into contact with a heat exchanger that contains low-pressure liquid refrigerant, transforming it into a warmer low-pressure gas. This process transfers heat from the air in the home to the refrigerant. After cooling, the air is pumped back into the return vents. The warm low pressure refrigerant gas goes outside to the condensing unit, where the compressor does its job by compressing the gas into a smaller space, resulting in a hot, high pressure gas. A fan pulls outside air past another heat exchanger containing the hot high-pressure refrigerant gas. The gas cools as it releases heat to the atmosphere and condenses back into a liquid. The liquid refrigerant goes back into the house to the expansion valve that turns it into a cold low pressure liquid to get more heat in the indoor heat exchanger and start the process again. After this process, the room must be cooled enough to the desired temperature. This process can be run in reverse mode, i.e. to heat up the room. Most of the air conditioners have their capacity rated in British thermal units (BTU). A BTU is the amount of heat required to raise the temperature of one pound (0.45kg) of water by one degree Fahrenheit (0.56℃). Therefore, 1 BTU is equal to 1,055 Joules. In heating and cooling terms, 1 'ton' is equal to 12,000 BTU's/per hour

**93. Mention the salient features of maintenance of a refrigeration unit.**
**Ans:**
• Lubrication of moving parts (blower & condenser fan)
• Protection from high humidity
• Cleaning of air return filters from dust
• Keep condensers and evaporator clean from all materials (1 month/1 year)
• Keep drain pipes clean to avoid possible health risks (e.g. legionnaire disease)
• Avoid over lengths (not more than 15ms)
• Avoid kinks and too many bends
• Think of means of oil return to compressor
• Provide adequate room for the recirculation of hot air and fresh air replacement.
• Flouring must be done properly
• No cross wiring (power / extra low voltage).
• Top up of refrigerant to dry procedure.
• Recirculation of nitrogen during brazing of joints and fittings.
• Dehydration of entire installation.
• Pressure test with nitrogen.

**94. Explain CFC refrigerants.**
**Ans:** CFC Chloro-fluoro Refrigerants like R-12,13

➢ Low toxicity, noncorrosive, and compatible with other materials

➢ Not flammable or explosive

➢ Heat can cause them to break down into their elements (harmful to humans-respiratory system especially)

➢ Harmful to environment (must follow strict EPA regulations)

**95. Explain HCFC refrigerants.**
Ans: HCFC Refrigerants like R-22

➢ Composed of methane/ethane in combination with a halogen

➢ Have shorter life

➢ Cause less ozone depletion (reduced global warming potential)

➢ Used as replacements until long term alternatives are available

➢ EPA requires phase out by 2030

**96. Explain HFC Refrigerants.**

Ans: HFC Refrigerants

- Contain one or more hydrogen atoms & no chlorine atoms
- Have no ozone depletion potential (very little effect on global warming)
- Typically used in new systems specially designed for their use
- Synthetic lubricating oils must be used
- Retrofitting of old systems to meet standards necessary to use these.

**99. What is Effective Room Sensible heat load (ERSHL)?**

Ans: ERSHL = RSHL + BPF x Ventilation SHL = RSHL + BPF x OASHL

ERSHL = RSHL + 0.2044 V ($t_{dbo}$ - $t_{dbi}$ ) x BPF

Where V is volumetric flow rate ($m^3$/min) of ventilation air

ERLHL = ERLHL + BPF x Ventilation SHL = RLHL + BPF x OALHL

ERLHL = ERLHL + BPF x 50 V ($\omega_0$ - $\omega_i$)

Where $\omega_0$ and $\omega_i$ are outside and inside specific humidities of air

100. What is Grand Sensible Heat Factor (GSHF)?

Ans: GSHF = GSHL/(GSHL + GLHL )

GSHL = RSHL + OASHL

GLHL = RLHL + OALHL

**101. Explain the procedure on Psychrometric Chart for the design of air conditioning apparatus.**

Design procedure means locating of different points on the psychometric chart to find the followings:

(i) Inside Design Conditions

(ii) Outside Design Conditions

(iii) Condition of Mixture of recirculated and fresh air

(iv) Location of alignment circle point ( $26^0$C, 50 % RH point)

(v) Location of SHF on the SHF scale in the upper right corner of the chart.

(v) Supply air condition from the cooling coil

(vi) **ADP (Apparatus Dew Point Temperature**) i.e. Temperature of Cooling Coil

**102. What are the modifications required for an existing R-12 refrigeration system to be retrofitted to R-134a refrigerant?**

**ANS:** Change of suitable lubricating oil and more effective moisture removal chemical.

**103. Give the brief description of any two of the following refrigeration and air conditioning equipment: (a) Rotary compressors, (b) Flooded expansion valve, (c) Natural draft cooling towers.**

**ANS: Rotary Compressors:** There is a stator and a rotor. The rotor is eccentrically mounted in the stator. It is suitable for pressure difference between condenser and evaporator as > 1.5 bars and < 3.5 bars. It also requires that the volume to be handled at the inlet of the compressor is neither small nor large. Iso-butane is the refrigerant suitable for such compressors. $NH_3$ and R-22 have small volumes and R-114 has large volume at the inlet of the compressor having the same tonnage capacity and same operating conditions in the evaporator.

**FLOODED EXPANSION VALVES:**

**NATURAL DRAFT COOLING TOWERS:**

**What are the various losses in the ducts of air conditioning systems?**

ANS: **Losses in a duct**

(i) **Frictional loss**: These are proportional to velocity and length and inversely proportional to diameter. These losses can be minimized by taking diameter of the duct same as diameter of the fan at the inlet.

(ii) **Shock loss:** These occur wherever there is a sudden change in the direction of flow or sudden change of area of flow. Even gradual transition in area of flow causes this loss. For example a taper of $3.5^0$ produces 22% loss of velocity head pressure. An angle of $30^0$ or more causes a pressure drop equivalent of velocity head pressure.

(iii) **System effect loss:** these are due to flow pattern changing at entrance or at the exit of the duct. These are often overlooked**.**

**104. What is an air washer?**

**ANS:** It is an arrangement in which **preheated air** is passed through a spray of water where it is **humidified and cooled** and **then reheated** to reach the required state.

**105. Discuss the detail the various thermo physical properties of the refrigerant?**

**ANS:** (i) Normal boiling point must be lower than the temperature to be achieved. It will ensure positive pressure inside the refrigeration system. This helps to detect leakage as there will be an outside leakage. In case of a inside leakage air, water and dust enters the system and all these have undesireable effects .

(ii) High latent heat: It will ensure that the quantity of refrigerant used is less.

(iii) specific volume at evaporator conditions: It must be low to limit the size of compressor and reduce the power input.

(iv) Working pressures in evaporator and condenser must be above atmospheric to avoid vacuum operation.

(v) Power requirements: It should be least per ton of refrigeration to reduce the electricity bill.

(vi) Viscosity must be less.

(vii) Specific heat in the liquid and vapour should be high.

(viii) Thermal conductivity should be high for increased heat transfer in the evaporator and condenser.

**106. Enumerate the various leak detection techniques of CFC refrigerants?**

**ANS: (i)** Soap solution method

(ii) Halide( Alcohal) torch for Freon refrigerants

(iii) Electronic leak detector

**107. Explain the steam jet refrigeration system with the help of neat sketches?**

**108.Calculate,( a) relative humidity,( b) humidity ratio, (c) dew point temperature,(d) density and (e) enthalpy of atmospheric air when the DBT is $35^0$C and WBT is $23^0$C and the barometer reads 750 mm Hg.**

**ANS:** Plot the DBT and WBT on the psychrometric chart and read the values: RH= 36%, humidity ratio=15.25 g/kg of d.a., DPT =$17.8^0$C, Density =(1/0.89) kg/$m^3$ of d.a. h=68 kJ/kg

**109. Explain the importance of comfort chart.**

**Importance**: It suggests that a range of temperatures and relative humidity are possible to give the same degree of comfort and hence system becomes more flexible.

**110. Distinguish between water inter -cooling and Flash inter- cooling of a compound compression system.**

**ANS:** Water inter cooling: normally employed for cooling air while being compressed. Water inter cooling can be used in the case of refrigerant compressors as in ammonia compressors where temperature during compression becomes quite high.

Flash inter cooling: It is employed in multistage compression of refrigerants to make vapours desuper -heated to dry saturated state before going into the next compressor. It reduces the work input in the next compressor. Here water inter cooling is not possible because the temperature of

refrigerant after compression is much less than that of water temperature. Multi compressors in refrigeration are required only when the temperature to be achieved is very low say -80$^0$C or even lower temperature.

**111. Explain with a neat sketch the working of thermostatic expansion valve.**
**ANS**: In a thermostatic expansion valve it controls a constant degree of superheat at the outlet of the evaporator. A feeler bulb containing a cross charged( different fom the one being used in the system) refrigerant is attached to the outlet of the evaporator. Say the degree os superheat increases at the outlet of the evaporator due to the availability of more heat, the feeler bulbs feels it and operates the valve in the opening direction to increase the flow of refrigerant to keep the prefixed degree of superheat in the evaporator.

**112. What are the various leak detection systems used in refrigeration industry and explain any one.**
**ANS:** Leak detection methods: Soap solution method, Halide torch method, Electronic method.
Soap Solution Method: Apply soap solution to the suspected points of leakage i.e. joints. If leakage is there bubble formation will take place indicating leakage.

**113. Differentiate between split A.C system and window A.C system.**
**ANS.** Split A.C. System: evaporator cabinet can be placed anywhere in the room to be air conditioned, Condensing unit is placed outside the room or outside the house at a convenient location. Lengths of tubes , number of joints and number of bends carrying the refrigerants are increased and the chances of leakage are more. The pressure drop will increase and hence the running charges will increase. But there is no change in the room or in the window.

Window A.C. System: The air conditioner is fitted in the window such that the cooling coil is towards the inside of the room and condensing unit is towards the outside of the window. Hot air from the condenser will available in the corridor which is not liked. But the operating and installation charges will be less in the case of window air conditioner as compared to the split A.C. system.

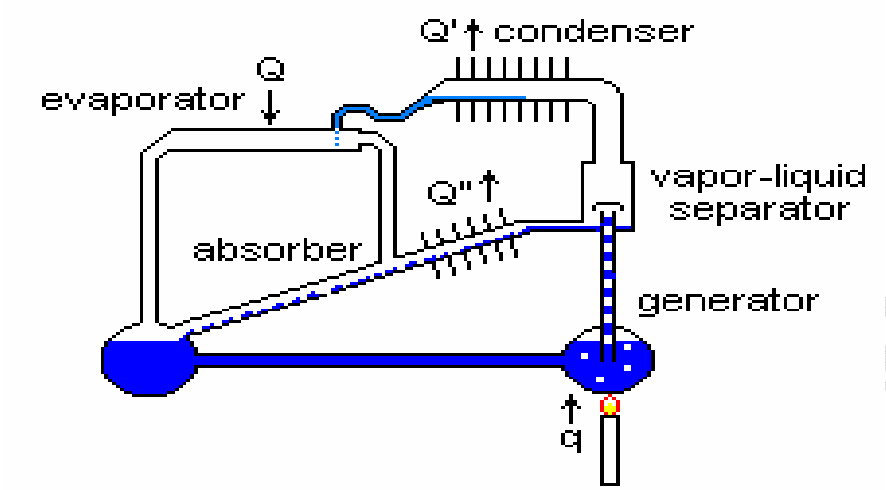
**114. Differentiate between Ventilation load and Infiltration load.**
**ANS:** Ventilation load: heat load added to the room (in turn added to AC) due to fresh air brought in the room to maintain the oxygen content in the room air.
Infiltration Load: Heat load added to the room (in turn to AC) due to the opening of door of the air conditioned room.

**115. Write the advantages of cooling towers used in Refrigeration Industry.**
**ANS:** The advantage of cooling tower is **significant reduction in the cost of water used in the condenser**.The cooling tower is normally placed at the roof of the building thus it **does not need any special space**.

**116. Difference between Heat engine and Heat pump.**
**ANS:** Heat Engine converts heat energy into motion or Mechanical energy Like Internal combustion engine in a scoter, car, bus etc.
Heat Pump: It is a device to heat the room in winter with comfortable conditions i.e. controls temperature, humidity, velocity and purity of air i.e. it is a winter air conditioner.

**117. Compare open cycle and closed cycle Refrigeration system.**
**ANS:** OPEN CYCLE: It relates the refrigeration cycle in an aircraft where the primary refrigerant is air. The conditioned air is open to the cabin i.e. cooled air comes in physical contact with the passgeners.i.e. air cycle is an open cycle.
CLOSED CYCLE: when the conditioned air do not come in contact with the passageners rather there is a heat exchanger in the cabin of the aircraft. Cabin air get cooled by coming in external contact with the cooling coil and recirculates into the cabin. In this case working pressures are high but air does not pick up moisture from the cabin as is the case in open air cycle.

**118. Draw the sketch of Electrolux Refrigeration system.**
**ANS:**




**Electrolux Refrigerator**

**119. Write applications of steam jet Refrigeration and mention its limitations.**
**ANS:** APPLICATIONS: It can be used in the industries where waste steam is available from a process namely in a paper industry, in a leather industry, in a brewery etc.
LIMITATION: Needs a boiler to produce steam where steam is not available and is likely to become costly affair.

**13.Give a brief account of Vortex refrigeration system giving suitable sketches. Compare the vortex refrigeration system with conventional vapour compression refrigeration systems.**

**122. How do traditional CFCs and HCFCs affect ozone layer? Describe briefly the effects of ozone depletion on environment?**
**ANS:** CFC REFRIGERANTS: These have high Global Warming potential and also high Ozone Depletion Potential as chlorine life in atmosphere is around 100 years. It is only chlorine which depletes the ozone layer like R-12 and R-11.
HCFC REFRIGERANTS: like R-22 has much less GWP and ODP than R-12.
Effects of Ozone depletion:

(i) Ultra violet rays will reach the earth and will reduce the crop output as well as its quality.
(ii) Children by birth will have body defects.
(iii) Wounds healing will become much longer.
(iv) Eye cataract will increase few thousands percent.
(v) Skin diseases will be on the rise.
(vi) More and more dangerous virus will be in the atmosphere.

**123. Give the brief description of any two of the following refrigeration and air conditioning: (a) Hermetically sealed Reciprocating compressors, (b) Shell and Tube condensers, (c) Package air conditioning units.**

**ANS:** Hermetically sealed Reciprocating Compressor: The motor, the compressor and the lubricating oil is placed in one dome. The RPM of compressor and motor are same and it is 2800 RPM. The dome contains three pipe lines namely suction pipe, discharge line and the charging line

which is normally pinched off in the normal working and is used while charging of refrigerant. It has suction reed and discharge reeds in place of suction and discharge valves to make it cheaper.
Shell and Tube Condensers: The refrigerant passes through the shell (Cylinder) and the water passes through the tubes. There are number of straight tubes and hence there are no bends to reduce the pressure drops and it is also easy to clean the tubes when the scale is formed in the tubes.
Package Air Conditioning Units: It is factory assembled unit like a window air conditioner. These units are of nearly 10 tons cooling capacity and their condensers are water cooled.

**124. Differentiate between working of window and split air conditioners.**
**ANS:** There is a difference in the layout first. In window air conditioner it is placed in the middle of the window with evaporator inside the room and the condensing unit being facing outside the room. In case of split air conditioner the evaporator is placed inside the anywhere and the condensing unit is placed outside the room at a convenient location. The pressure drop is more in split unit and hence running charges are more. The chances of leakage are more since the refrigerant pipe lines are of much greater length in the split units.

**125. What are the modifications required for an existing R-12 refrigeration system to be retrofitted to R-134a refrigerant?**
**ANS:** (i) The lubricant has to be changed.
(ii) The R-134a should be totally free of moisture.
(iii) The condenser and evaporator are to be redesigned.

**126. Enumerate the characteristics requirements of refrigerant, absorber and mixture in vapour absorption refrigeration systems.**
**ANS** (i) The absorbent should have high affinity for the refrigerant at the evaporator conditions and least affinity at generator conditions.
(ii)The absorbent and the refrigerant mixture should form an ideal liquid mixture.
(iii) The boiling points of absorbent and refrigerant should be far apart.

**127. Define the term COP of a refrigeration system. What are factors affecting COP of a refrigeration system?**
**ANS:** COP= N/ W, N=cooling effect/kg, W= work input/kg, COP of a refrigeration of a vapour compression system is > 1.
Factors affecting COP: (i) degree of superheat, (ii) degree of sub-cooling, (iii) evaporator pressure, (iv) condenser pressure, (v) temperature to be achieved

**128. Enumerate the desirable properties of refrigerants commonly employed in refrigeration and air conditioning applications.**
**ANS:** Desirable properties of a refrigerant: Lower boiling point, lower freezing point, lesser specific volume, high latent heat, less work input/kg of refrigerant, high COP, minimum running charges, non-toxic, non- inflammable, inert, non decomposable, less leaking tendency, leakage easily detectable, cheap, easily available in abundance and everywhere, chemically inert with the material of construction, materials being cooled and the lubricant, less viscosity, high specific heat and high thermal conductivity.

**129. Differentiate between an air conditioner working on reverse cycle in winter to produce heating effect and an air conditioner employing an electric heating filament to produce required heating effect. Which air conditioner will you prefer and why?**

**ANS:** Air conditioner working on reverse cycle will have higher COP than when it was being used for cooling. Hence running charges will be reduced. Heating provided will be much greater than the electricity consumed i.e. heating effect will be higher than cooling effect. Hence air conditioner working on reverse cycle must be preferred.

**130. Derive the term 'refrigeration effect'. Derive the unit of refrigeration in S.I.Units**.

ANS. Refrigeration effect is $N=h_1 - h_4$ kJ/kg
**Unit of ref.=1 TR in S.I.Units = 211 kJ/min**= 2000 x 144/(24 x 60) =200 BTU/min= 211 kJ/min

**131. Describe the effect of superheating on performance of ref.units.**
**ANS.** Up to $5^0$ of superheat, COP increases. For than $5^0$ of superheat COP decreases.

**132. What do understand by the term cascading in refrigeration system?**
**ANS:** Using coupled independent two refrigeration circuits to produce temp
$-55^0$C or using coupled independent three refrigeration circuits to produce temp of $-80^0$C.

**133. What do understand by adiabatic saturation temperature?**
**ANS:** Achieving saturation temperature with no gain of heat from the surroundings or no loss of heat To the surroundings.

**134. What are the main sources of heat in the aero plane cabin?**
Ans.(i) SENSIBLE HEAT GAINS
Solar heat gains through walls, roof and floor
Solar heat gains through glass
Sensible heat gain from occupants
Sensible heat gains from light
Sensible heat gain from power equipments
Sensible heat gain from Products (Potatoes, Bananas, apples etc.)
Sensible heat gain from infiltrated air
Sensible heat gains from ventilation air
Sensible heat gains through miscellaneous sources

(ii) LATENT HEAT GAINS:
Latent heat load only due to moisture difference.
Examples: Latent heal from occupants
Latent heat load from infiltrated air

Latent heat gains from ventilation air
Latent heat gains from miscellaneous sources

**135. The COP of a unit is 5 and it extracts 8350 kJ/min. Find the power required to run the compressor.**
ANS:
COP=N/W i.e. 5=8350/W
W=1670 kJ/min=**28 kW**

**136. What are the main components of a vapor compression system?**
ANS. Compressor, condenser, Expansion valve, Evaporator, Piping and refrigerant.

**137. What are the main components of a vapor absorption unit?**
**ANS.** Condenser, Expansion valve, evaporator, absorber, aqua pump, aqua heat exchanger, generator, another expansion valve, analyzer, rectifier

**138. Give two examples of ideal refrigerant-absorbent combinations.**
**ANS:** Ammonia and water
Water and lithium bromide.