**UNIT -1**

1. Derive the expression for COP of Carnot vapour compression refrigeration system
2. a) Explain refrigeration system using Brayton cycle and show the state points on Temperature-Entropy diagram considering the irreversibilities.

b) A dense air refrigeration machine operating on Bell-Coleman cycle operates between 3.4 bar and 17 bar. The temperature of air after the cooler is 150C and after the refrigerator is 6 0C. For a refrigeration capacity of 6 tonnes, find: (i) Temperature after compression and expansion, (ii) Air circulation required in the cycle per minute, (iii) Work of compressor and expander, (iv) Theoretical C.O.P and (v) Rate of water circulation required in the cooler in kg/min, if the rise in temperature is limited to 300C.

1. Discuss the advantages and disadvantages of air-refrigeration system. Explain the necessity of cooling aircrafts?

b) An ice plant is working on a reversed Carnot cycle produces 15 tons of ice per day. The ice is formed at 00 C and water supplied is also at 00 C. The heat is rejected to atmosphere at 250C. The heat pump used to run the plant is coupled to a Carnot engine receives heat from a source at 2200 C and it rejects the heat to atmosphere. The fuel Calorific value, 44.5 MJ/kg is used for supplying the heat. Determine the following (i) power developed by the engine and (ii) fuel used/hr. Take enthalpy of fusion of ice=334.5 kJ/kg.

1. a) Explain Boot-strap air refrigeration system with neat diagram.

b) A Refrigerator working on Bell-Coleman cycle takes air into the compressor at 1 bar and –50C. It is compressed in compressor to a 5 bar and cooled to 250C at the same pressure. It is further expanded in the expander to 1 bar and discharged to take cooling load. The isentropic efficiency of the compressor = 85% and the isentropic efficiency of the Expander = 90% find the following: i) Refrigerating capacity of the system if air circulation is 40kg/min. ii) KW capacity of motor required to run the compressor iii) COP of the system. Take ᵞ =1.4 Cp =1kJ/kg Cv = 0.7 kJ/kg for air [8M] c) A machine working on a Carnot cycle operates between 305K and 260 K. Determine the COP when it is operated as i) Refrigerator ii) Heat pump and iii) Heat engine

1. a) An air refrigeration open system operating between 1Mpa and 100kpa is required to produce a cooling effect of 2000 kJ/min. Temperature of the air leaving the cold chamber is -5oC and at leaving the cooler is 300C. Neglect losses and clearance in the compressor and expander. Determine: i) Mass of air circulated per minute ii) Compressor work, expander work, cycle work iii)C.O.P and power in kW required

b) Give a brief description of an ideal cycle of air refrigeration.

1. a) An air refrigeration system operating on Bell Coleman cycle takes in air from cold room at 260 K and compresses it from 1.0 bar to 5.5 bar. The index of compression being 1.25. The compressed air is cooled to 300 K. The ambient temperature is 200C. Air expands in an expander where the index of expansion is 1.35. Calculate: (i) C.O.P. of the system (ii) Quantity of air circulated per minute for production of 1500 kg of ice per day at 00C from water at 200C. (iii) Capacity of the plant in terms of kJ/s. Take cp = 4.18 kJ/kg K for water, cp = 1.005 kJ/kg K for air, Latent heat of ice = 335 kJ/kg.

b) Explain Bootstrap aircraft refrigeration system.

1. Define refrigeration. State the Name of different types of system used for cooling of aircraft cabin.

b) An air refrigerator working on Bell-Coleman cycle takes in air at 1 bar and at a temperature of 100 C. The air is compressed to 5 bar abs. The same is cooled to 250 C in the cooler before expanding in the expansion cylinder to cold chamber pressure of 1 bar. The compression and expansion laws followed are pv1.35 = C and pv1.3 = C respectively. Determine C.O.P of the plant and net refrigeration effect per kg of air. Take Cp = 1.009 kJ/kg K and R = 0.287 kJ/kg K for air. With the help of a neat sketch explain the air conditioning system used in aircrafts.

1. Draw the schematic of a boot-strap evaporative cycle of air refrigeration system, and show the cycle on T-s diagram.

b) A regenerative air refrigeration system for an air plane has to take 30 ton of load, while the ambient conditions are 0.80 bar and 70C. The ramming action leads to a pressure rise from 0.8 bar to 1.2 bar at constant entropy. The air is bled off the main compressor at 4.8 bar. The ram air heat exchanger is 60% effective. The air from the heat exchanger passes on to cooling turbine. Some portion of the air after expanding in the cooling turbine passes on to the regenerative heat exchanger reducing the temperature of the main compressed air to 500C. The cooling air from turbine gets heated to 1000C before discharging. The isentropic efficiencies of the compressor and the turbine are 90% and 80% respectively. The cabin is pressurized to 1 bar and maintained at 250C. Determine (i) The ratio of the air extracted from cooling turbine for regenerative cooling of the ram air, (ii) Power required for maintaining the cabin at required condition. Assume the cooling turbine power developed to be used for ram air exhaust fan. Discuss the advantages and disadvantages of air-refrigeration system. Explain the necessity of cooling aircrafts?

1. a)Draw the schematic of a boot-strap cycle of air refrigeration system, and show the cycle on T-s diagram.

b) In a boot-strap refrigeration system for an aircraft the ambient conditions are 0.225 bar and -50C. Cooling load estimate is 20 ton refrigeration (20 TR). The speed of the plane is 1000 km/hr. Ram efficiency is 0.9. the pressure ratio for the main compressor is 3.5 and this bled off air is further compressed in secondary compressor run by cooling air turbine on a single shaft such that output from turbine is equal to input to the compressor. The internal efficiency of main compressor as well as secondary compressor is 0.9, and that of cooling turbine is 0.8. The air from secondary compressor is cooled by ram air to 500C. The cooling air turbine running the secondary compressor has its exit pressure of 1 bar. Determine (i) Delivery pressure from the secondary compressor, (ii) Mass flow rate bled for cooling the cabin, (iii) COP of the system. A dense air refrigeration machine operating on Bell-Coleman cycle works between 3.4 bar and 17 bar. The temperature of air after the cooler is 15oC and after refrigeration is 6oC, for a refrigeration capacity of 6 tons Calculate: i)Temperature after compression and expansion ii)Air circulation required in cycle per minute iii)Work of compression and expansion iv)Theoretical COP v)Rate of water circulation required in the cooler in Kg/min if rate of temperature rise is limited to 30oCExplain the factors considered in selecting the refrigeration system for aircrafts.

1. a) Explain the difference between simple air craft refrigeration and boot-strap air refrigeration system. [6M]

b) An air refrigerator working on Bell-Coleman cycle takes air into the compressor at 1 bar and 268 K. It is compressed in a compressor to 5 bar and cooled to 298 K at the same pressure. It is further expanded in the expander to 1 bar and discharged to take the cooling load. The isentropic efficiencies of the compressor and expander are 85% and 90% respectively. Determine : (i) Refrigeration capacity of the system if the air circulated is 40 kg/ min; (ii) Power required for the compressor; and (iii) C.O.P of the system. (a) Explain the working of simple air cycle cooling system used for air crafts.

(b) Describe working of simple air evaporative cycle cooling system used for air crafts.

1. (a) Describe Boot strap cycle of air refrigeration system, with schematic layout and show the cycle on T-s diagram

(b) Describe Boot strap air evaporative cycle of air refrigeration system, with schematic layout and show the cycle on T-s diagram.

1. (a) Explain with neat sketch, working principle of reduced ambient air cooling system. Draw T-s diagram for the system.

(b) Describe with a sketch, working of regenerative cooling system.

1. (a)What are the advantages of dense air refrigeration system over an open air refrigerating system?

(b) Even though the temperature is low at high altitudes, what is the necessity of cooling air in aero plane?

1. (a) Derive an expression for COP of air refrigeration system following Bell Coleman cycle.

(b) The atmospheric air at pressure 1 bar and temperature -50 C is drawn in the cylinder of the compressor of a Bell-Coleman refrigerating machine. It is compressed isentropically to a pressure of 5 bar. In the cooler, the compressed air is cooled to 150C, pressure remaining the same. It is then expanded to a pressure of 1 bar in an expansion cylinder, from where it is passed to the cold chamber. Find: (a)The work done per kg of air, and (b)C.O.P. of the plant. (c)For air assume law for expansion PV1.2 = constant. Law for compression PV1.4 = constant and specific heat of air at constant pressure = 1kj/kg.k.

1. An air craft refrigeration plant has to handle a cabin load of 30 tonnes. The atmospheric temperature is 170C. The atmospheric air is compressed to a pressure of 0.95 bar and temperature of 300C due to ram action. This air is then further compressed in a compressor to 4.75 bar, cooled in a heat exchanger to 670C, expanded in a turbine to 1 bar pressure and supplied to the cabin. The air leaves the cabin at a temperature of 270C. The isentropic efficiencies of both compressor and turbine are 0.9. Calculate the mass of air circulated per minute and the C O P for air, cp=1.004kJ/kg K and λ = 1.4.
2. Draw the schematic of a boot-strap cycle of air refrigeration system, and show the cycle on T-s diagram. [8M] b) A cold storage plant is required to store 20 tonnes of fish. The fish is supplied at a temperature of 30°C. The specific heat of fish above freezing point is 2.93 kJ/kg K. The specific heat of fish below freezing point is 7.26 kJ/kg K. The fish is stored in cold storage which is maintained at -80C. The freezing point of fish is -40C. The latent heat offish is 235 kJ/kg. If the plant requires 75 kW to drive it, find: i) The capacity of the plant, and ii) Time taken to achieve cooling. Assume actual C.O.P. of the plant as 0.3 of the Carnot C.O.P.
3. ) An air refrigerator working on the principle of Bell-Coleman cycle. The air into the compressor is at 1 atm at -10ºC. It is compressed to 10 atm and cooled to 40ºC at the same pressure. It is then expanded to 1 atm and discharged to take cooling load. The air circulation is 1 kg/s. The isentropic efficiency of the compressor = 80% The isentropic efficiency of the expander = 90% Find the following: i) Refrigeration capacity of the system ii) C.O.P of the system Take γ = 1.4, Cp = 1.00 kJ/kg ºC (solution)
4. Explain Boot strap evaporative cooling air refrigeration system. Draw its schematic and represent the processes on T-S diagram. Write down the equations for calculating mass flow rate, power and COP of the system.
5. An air craft moving with speed of 1000 km/h uses simple gas refrigeration cycle for air conditioning. The ambient pressure and temperature are 0.35 bar and -100C respectively. The pressure ratio of compressor is 4.5. The heat exchanger effectiveness is 0.95. The isentropic efficiencies of compressor and expander are 0.8 each. The cabin pressure and temperature are 1.06 bar and 250C. Determine temperature and pressures at all points of the cycle. Also find the volume flow rate through compressor inlet and expander outlet for 100 TR. Take CP=1.005 kJ/kg K; R=0.287 kJ/kg K and CP/CV=1.4 for air.
6. In simple air refrigeration system the regenerative cooling reduces the temperature of air from the heat exchanger by 200C before it expands through the cooling turbine. The air leaves the cabin at 270C and the ram air temperature is 150C. Obtain the amount of air bleed from the refrigeration and COP. If 0.5 Kg/s of air from the main compressor is used for the air conditioning. Calculate the power requirement and tonnage of the system. Take Pamb= 0.8 bar, Pram= 1 bar, efficiency of compressor = 0.8, efficiency of turbine= 0.8, heat exchanger effectiveness is 0.75. The cool air leaves the regenerative heat exchanger at 270C. [8M] b) Explain the working principle of Regenerative air refrigeration system with the help of configuration diagram and temperature-entropy diagram.
7. A Bell-Coleman refrigerator operates between pressure limits of 1 bar and 8 bar. Air is drawn from the cold chamber at 90C, Compressed and then it is cooled to 290C before entering the expansion cylinder. Expansion and compression follows the law PV1.35=constant. Calculate the theoretical COP of the system. For air take ϒ =1.4, Cp=1.003 kJ/kg.K.
8. An aircraft is cruising with a speed of 900 kmph at an altitude of 11,000 metre where the ambient conditions are 0.3 bar and -30°C.Assuming the compression ratio 5, cabin pressure 0.8 bar and air leaving the cabin at 27°C,obtain the power for pressurization and refrigeration and COP. The flow rate through the system is 1.0 kg/s.

**UNIT-2**

1. (a) With a neat sketch, explain the working principle of vapour compression refrigeration system.

(b) Explain the effect of following parameters on VCR cycle

1. Wet Vapour after compression,
2. Super heated vapour after compression
3. Sub cooled liquid refrigerant before expansion.
4. (a) Effect of suction pressure and discharge pressure on VCR cycle.

(b) A vapour compression refrigerator works between the pressure limits of 60 bar and 25 bar. The working fluid is just dry at the end of the compression and there is no under cooling of the liquid before the expansion valve. Determine: i. C O P of the cycle and ii. Capacity of the refrigerator if the fluid flow is at the rate of 5 kg/min.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Pressure  (bar) | Saturation temp  (K) | Enthalpy (kj/kg) | | Entropy(kj/kg k) | |
| 60  25 | 295  261 | Liquid | Vapour | Liquid | Vapour |
| 151.96  56.32 | 293.29  322.38 | 0.554  0.266 | 1.0332  1.2464 |

1. (a)What are the desirable properties of an ideal refrigerant?

(b) 28 Tonnes of ice from and at 0oC is produced per day in an ammonia refrigerator. The temperature range in the compressor is from 250C to -150C. The vapour is dry and saturated at the end of compression and an expansion valve is used. There is no liquid sub cooling. Assuming actual COP of 62 % of theoretical, calculate the power required to drive the compressor. Following properties of ammonia are given:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Temperature (oC) | Enthalpy (KJ/Kg ) | | Entropy (KJ/Kg K) | |
| Liquid | Vapour | Liquid | Vapour |
| 25 | 298.9 | 1465.84 | 1.1242 | 5.0391 |
| -10 | 112.34 | 1426.54 | 0.4572 | 5.5490 |

1. (a) Explain the simple saturation cycle with flash chamber

(b) Explain the Simple saturation cycle with accumulator.

(c) Describe the simple saturation cycle with sub-cooling of liquid refrigerant by vapor refrigerant.

1. **(a)** Explain the Actual VCR cycle with T-s diagram.
2. (b) The temperature limits of an ammonia refrigerating system are 250C and 100C. If the gas is dry at the end of compression, calculate co-efficient of performance of the cycle assuming no under cooling of the liquid ammonia. Use the following data for the properties of ammonia:

|  |  |  |  |
| --- | --- | --- | --- |
| Temperature (oC) | Liquid Heat  (KJ/Kg) | Latent Heat  (KJ/Kg) | Liquid entropy  (KJ/Kg K) |
| 25 | 298.9 | 1166.94 | 1.1242 |
| -10 | 135.37 | 1297.68 | 0.5443 |

1. How does an actual vapour compression cycle differ from that of a theoretical cycle?

(b) A refrigeration plant of 100 tons capacity uses R-22 as refrigerant. The condensing and evaporation pressures are 11.82 bar and 1.64 bar. The refrigerant enters the condenser dry saturated and leaves the condenser sub cooled by 100C. Actual COP is 70% of theoretical COP. Cp of vapour = 0.55 KJ/Kg K, Cp of liquid = 1.19 KJ/Kg K. Find: i) Theoretical and actual COP, ii) mass flow rate in kg/sec, iii) compressor power. The other properties of refrigerant are as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Pressure**  **(bar)** | **Temperature**  **(0 C)** | **Specific Enthalpy**  **(kJ/kg)** | | **Specific Entropy**  **(kJ/kg-k)** | |
| **Liquid (hf)** | **Vapour (hg)** | **Liquid (Sf)** | **Vapour (Sg)** |
| 1.64 | -30 |  | 393.1 | 0.8698 | 1.803 |
| 11.82 | 30 | 236.7 | 414.5 | 1.125 | 1.712 |

1. (a) How does the increase in condenser temperature affect COP? Also explain the influence of evaporator temperature on COP. Which of the two temperatures have more influence on COP?

(b) The temperature limits of an ammonia refrigerating system operating on simple vapor compression cycle are 250C and – 100C respectively. If the gas is dry at the end of compression, calculate the C.O.P of the system, assuming no under cooling of the liquid ammonia.

|  |  |  |  |
| --- | --- | --- | --- |
| **Temperature**  **( 0C)** | **Liquid heat (kJ/kg)** | **Latent heat (kJ/kg)** | **Liquid entropy (kJ/kg-K)** |
| 25 | 298.9 | 1166.94 | 1.1242 |
| –10 | 135.37 | 1297.58 | 0.5443 |

1. (a) State merits and demerits of ‘Vapor compression system’ over‘ Air-refrigeration system’

(b) An ammonia ice plant operates between condenser temperature of 350C and an evaporator temperature of -150C. It produces 5 tonnes of ice per day from water at 250C to ice at -50C. The ammonia enters as dry saturated vapor and leaves the condenser as saturated liquid. Determine: (i) The capacity of the refrigerating plant (ii) Mass flow of the refrigerant (ii) Discharge temperature of ammonia from the compressor (iv) Power of the compressor motor if the isentropic efficiency of the compressor is 85% and mechanical efficiency of the compressor is 90% (v) Relative efficiency. The latent heat of formation of ice is 335 kj / kg and specific heat of ice is 2.1 kj / kg-k.

1. Explain the effect of sub cooling and superheating on the performance of vapour compression refrigeration system
2. A simple vapour compression plant produces 5 tonnes of refrigeration. The enthalpy values at inlet to compressor, at exit from the compressor and at exit from the condenser are 183.19, 209.41 and 74.59 kJ/kg respectively. Estimate: i) The refrigerant flow rate ii) The C.O.P. iii) The power required to drive the compressor iv) The rate of heat rejection to the condenser [8M]

b) Explain the effect of change in the following operating conditions on the performance of vapour compression refrigeration cycle using p-h chart. i) Evaporator pressure ii) Condenser pressure

1. A Freon 12 vapour compression system operating between -50C and 500C develops 15 TR. Determine i) mass flow rate of the refrigerant ii) piston displacement per ton iii) the Carnot COP and actual COP of the cycle.
2. (a) Under what circumstances super heating of refrigerant vapour before compression is objectionable?

(b) A single compressor using R-12 as refrigerant has three evaporators of capacity 30TR, 20TR and10TR.The temperature in the three evaporators is to be maintained at -10oC, 5oC and 10oC respectively. The condenser pressure is 9.609 bar. The liquid refrigerant leaving the condenser is sub-cooled to 30oC. The vapour leaving the evaporators is dry and saturated. Assuming isentropic compression, calculate i) the mass of refrigerant flowing through each evaporator; ii) the power required to drive the compressor; and iii) C.O.P. of the system.

1. (a) Explain the different methods of improving the COP of simple compression refrigeration cycle.

(b) Explain the effect of sub cooling on COP.

1. A vapor compression machine is used to maintain a temperature of - 230C in refrigerated space. The ambient temperature is 370C.The compressor takes in dry saturated vapor of F -12. Aminimum100C temperature difference is required at the evaporator as well as condenser. There is no sub-cooling of liquid. If refrigerant flow is rate is 1kg/min Find (i)Tonnage of refrigeration. (ii)Power requirement (iii)Ratio of COP of this cycle to COP of Carnot cycle.
2. (a) Explain standard vapour compression refrigeration cycle with T-S and P-H diagram.

(b) Mention the advantages of vapour compression refrigeration system over air refrigeration system.

1. A R-12 vapour compression system has saturated suction temperature of -5°C and saturated discharge temperature of 40°C. The refrigerant vapour is dry-saturated at the suction of compressor and becomes superheated after compression. For one ton of refrigeration capacity, Calculate i)Refrigerating effect ii)mass flow rate iii)Power and iv)COP of the system
2. A refrigerating unit is working between 40oC and –10oC. The load on the unit is 5 tons. Assume the refrigerant is NH3 which is dry and saturated vapour leaving the evaporator and compression is isentropic. Find (i) COP of the system (ii) Power required to run the system. If the temperature of the refrigerant required in the evaporator is –20oC, then find the change in C.O.P. of the system and power required.
3. (a)With the help of a neat sketch explain the working of a simple vapour compression refrigeration system

(b) In an ammonia vapour compression refrigerator, the temperature of refrigerator is -100C. The vapour is condensed in a condenser at 300C. Find the theoretical C.O.P of the cycle when the vapour at the end of compression is 0.9 dry. Take latent heat of NH3 AT 300C = 1442 KJ/Kg, specific heat of liquid NH3 = 4.7 KJ/Kg

1. What is the effect of sub cooling and super heating in vapor compression process and show it in T-S and h-s diagram?

b) An ammonia ice plant operates between a condenser temperature of 300C and an evaporator temperature of -200C. It produces 10 tons of ice per day from water at 250C to ice at -100C. Assuming simple saturation cycle, determine: i) the capacity of refrigerating plant ii) mass flow rate of refrigerant and iii) COP of the cycle.

1. (a)Draw the refrigerator cycle on T-s diagram when the refrigerant is dry and saturated at the end of compression and find an expression for the COP in terms of temperature and entropies. [6M]

(b) A vapour compression machine is used to maintain a temperature of -230 C in a refrigerated space. The ambient temperature is 370 C. The compressor takes in dry saturated vapour of F-12 refrigerant. A minimum 100 C temperature difference is required at the evaporator as well as the condenser. There is no sub-cooling of the liquid. If the refrigerant flow rate is 1 kg/min, find (i) Tonnage of the refrigerant; (ii) Power requirement and (iii) COP of the cycle

**UNIT -3**

1. List the different types of compressors? And explain each type usage in refrigeration systems giving proper reasons.
2. Where centrifugal compressors are preferred over reciprocating compressors in refrigeration systems? Describe the advantages and disadvantages of centrifugal over reciprocating compressors.
3. List out differences between rotary compressors and reciprocating compressors
4. Where air-cooled condensers are preferred over water-cooled condensers? Give examples with specific reasons.
5. With the help of a neat sketch, explain the working of an evaporative condenser.
6. Explain the working of evaporative condenser with neat diagram and explain its advantages and disadvantages over others. Give three examples of its use with proper reasoning.
7. Write a note on i) Shell and tube condenser ii) Screw compressor.
8. How condensers and evaporators are classified? Explain any one of the condenser and evaporators with the help of neat sketch.
9. Classify the Evaporators used in refrigeration system and explain the working of flooded type Evaporator with a neat diagram
10. Explain the working of Flooded evaporator with neat sketch. Specify the fields of their applications.
11. What are the advantages of thermostatic expansion valve? Describe its operation.
12. Explain construction, working, advantages and disadvantages of Thermostatic Expansion valve with neat sketch. Explain the working of automatic expansion valve.
13. Explain the operation of a capillary tube in a refrigeration system with a neat sketch
14. Give the comparison between air cooled and water cooled condenser. Explain in detail an evaporative condenser.
15. Explain the working of following types of evaporators with neat sketches: (i) Shell and tube evaporator, (ii) Forced convection evaporator, (iii) Shell and coil evaporator.
16. Discuss the operation of a capillary tube in a refrigeration system.
17. Explain the working principle of thermostatic expansion valve with the help of a neat diagram.
18. Write short notes on the types of refrigeration compressors. [8M] b) Explain the working of following types of evaporators with neat sketches: (i) Flooded evaporator, (ii) Natural convection evaporator.
19. Explain the classification of evaporators and working of any one.
20. Compare the performance of Reciprocating and Centrifugal compressors.

**UNIT-4**

1. a)Explain, with the help of a neat diagram, the working of Ammonia-Water absorption system.

b)Make a comparative list between vapour absorption system and a compression system.

1. Explain with constructional features and working of Practical vapour absorption refrigeration system with neat sketch,
2. Explain with help of neat sketches, vapour absorption cycle for refrigeration. How is it different from vapour compression refrigeration system. Explain, with the help of a neat diagram, the working of Ammonia-Water absorption system.
3. Explain with constructional features and working of Practical vapour absorption refrigeration system.
4. State the advantages and disadvantages of Electrolux refrigerator over conventional refrigerators.
5. Explain with neat sketch working of Electrolux Refrigerator also explain significance of Hydrogen used in system.
6. Compare between a two-fluid and three-fluid vapour absorption system.
7. Draw a neat compact diagram of lithium bromide water absorption refrigeration system and explain its working. List out the major fields of applications of this refrigeration system?
8. With a neat sketch explain the working principle of steam jet refrigeration system what are the merits and demerits of steam jet refrigeration system and name few applications?
9. For a steam jet refrigeration system, the steam enters the nozzle at 8 bar just dry saturated state. The condenser pressure is 0.07 bar and flash chamber is to be maintained at 50 C. The make-up water enters the flash chamber at 350 C. Taking nozzle, entrainment and compressor efficiencies are ηn=0.94, ηe=0.75 and ηc=0.65 respectively, compute (i) amount of steam per kg of vapour formed in the flash chamber, (ii) COP, and (iii) volume of vapour leaving the flash chamber per ton per hour.
10. With a neat sketch explain the working of Vortex tube refrigerator.
11. Explain working principle and components of thermo electric refrigerating system. Explain the merits and demerits of thermo electric refrigeration system

**UNIT-5**

1. Calculate the following when the DBT is 350C, WBT is 230C and the barometer reads 750mm Hg: (i) Relative humidity ii) Humidity ratio iii) DPT iv) Density (v) Enthalpy of atmospheric air.
2. State and explain various heat loads to be considered for cooling load calculations of a typical building
3. A small office hall of 25 persons capacity is provided with summer air conditioning system with the following data:

Outside conditions = 340 C DBT and 280 C WBT

Inside conditions = 240 C DBT and 50 % RH

Volume of air supplied = 0.4 m3/min/person

Sensible heat load in room = 125600 kJ/h

Latent heat load in the room = 42000 kJ/h. Find the sensible heat factor of the plant.

1. The following data apply to an air conditioning system:

Room sensible heat = 41778 kJ/hr; room latent heat = 41778 kJ/hr; inside design condition= 280C, 50% RH, outside design condition=350C, DBT, 27.6 WBT. Return air from the room is mixed with the outside air before enteringthe cooling coil in the ratio of 4:1. Return air from the room is mixed with the cooling air, i.e. after the cooling coil in the ratio of 1:4. Cooling coil by pass factor is 0.1. The air may be reheated if necessary before supplying to the conditioned space. Assume ADP as 120C and determine:

* 1. Supply air conditions into the room
  2. Refrigeration load due to the reheat
  3. Total refrigeration capacity
  4. The quantity of fresh air supplied.

1. An air-conditioned auditorium is to be maintained at 270C DBT and 60% RH. The ambient condition is 400C DBT and 300C WBT. The total sensible heat load is 100 000 kJ/h and total latent heat load is 40000 kJ/h. 60% of the return air is re-circulated and mixed with 40% of makeup air after cooling coil. The condition of air leaving the cooling coil is at 180C. Determine i) RSHF, ii) The condition of air entering the auditorium, iii) The amount of make-up air, iv) ADP and v) BPF of cooling coil.
2. Explain the following: i) Bypass factor, ii) Effective sensible heat factor.
3. Discuss their importance in designing air conditioning system.
4. The following data apply to an air conditioning system: Room sensible heat = 41778 kJ/hr; room latent heat = 41778 kJ/hr; inside design condition= 280C, 50% RH, outside design condition=350C, DBT, 27.6 WBT. Return air from the room is mixed with the outside air before entering the cooling coil in the ratio of 4:1. Return air from the room is mixed with the cooling air, i.e. after the cooling coil in the ratio of 1:4. Cooling coil by pass factor is 0.1. The air may be reheated if necessary before supplying to the conditioned space. Assume ADP as 120C and determine: i) Supply air conditions into the room ii) Refrigeration load due to the reheat iii) Total refrigeration capacity iv) The quantity of fresh air supplied.
5. Sketch the psychrometric chart and represent the different psychrometric properties on the same.
6. Calculate the following when the DBT is 350C, WBT is 230C and the barometer reads 750mm Hg: (i) Relative humidity ii) Humidity ratio iii) DPT iv) Density (v) Enthalpy of atmospheric air.
7. In an air conditioning system air at a flow rate of 2 kg/s enters the cooling coil at 25oC and 50% RH and leaves the cooling coil at 11oC and 90% RH. The apparatus dew point of the cooling coil is 7oC.Find i) The required cooling capacity of the coil, ii) Sensible Heat Factor for the process, and iii) By-pass factor of the cooling coil. Assume the barometric pressure to be 1 atm. Assume the condensate water to leave the coil at ADP (hw= 29.26 kJ/kg)
8. Describe the following psychrometric processes i) cooling with dehumidification ii) cooling with adiabatic humidification.
9. Atmospheric air having DBT=160C and RH=25% is passed through a furnace and then through a humidifier to maintain a final DBT of 300C and 50% R.H. Find the heat and moisture added to the air during the process. Also calculate the sensible heat factor of the process.
10. a)Explain the following: i) Bypass factor, ii) Effective sensible heat factor.

b)Discuss their importance in designing air conditioning system.

1. Air with Tdb=300 C contains 15 grams of moisture/kg of dry air. Calculate (i) dew point, (ii) relative humidity, (iii) degrees of saturation and (iv) specific humidity. Also find as to what would be the enthalpy of this air.

**UNIT – 6**

1. Define the term ‘effective temperature’ and explain its importance in air conditioning system. Describe the factors which affect effective temperature?
2. (a)Explain the importance of `throw` and `drop` in locating the grill.

(b) Write short notes on axial flow fans and centrifugal fans.

1. (a)Define the ``human comfort`` and explain the factors which affect human comfort.

(b)Explain the use of ``heat-pump`` for heating and cooling cycle with neat diagrams.

1. (a)Discuss different methods of humidifying the air?

(b)Make the arrangement of ``heat-pump`` when it is used for year-round air conditioning.

1. (a)Write short notes on grills and registers.

(b)What is the function of a filter and how are filters classified?

1. (a)Give few industrial examples where heating and cooling is simultaneously required and explain why ``heat-pump`` is more suitable for such applications.

(b) Discuss different methods of humidifying the air?

1. What is comfort air-conditioning? Draw a rough comfort chart.
   1. Explain any two types of humidifiers.
   2. Explain the principle of various dehumidification methods.
2. a)Briefly explain the requirements of comfort air conditioning [8M]

b)What are the different types of fans used in air-conditioning systems? Discuss their applications with their relative advantages and disadvantages.

1. What do you understand by Grills and Registers? Explain any two factors which affect Grill performance.
2. Classify the heat pump circuits and explain air-air heat pump circuit with a neat diagram.
3. a)With the help of a circuit diagram explain how a single air conditioning unit is used as an air-conditioner in summer and heat pump in winter.

b) Explain about Grills and Registers along with their performance effects

1. a) With a neat sketch explain the working of winter air conditioning system.

b) With neat sketch explain construction and working of any one type of humidifier.Explain in detail the factors that govern optimum effective temperature.