REFRIGERATION & AIRCONDITIONING

***Time**: Three Hours*

***Maximum Marks**: 100*

Answer five questions, taking ANY TWO from Group A, any two from Group B and all from Group C.

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches.

Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (a) Define the following terms: 6

   (i) C.O.P.

   (ii) Relative C.O.P.

   (iii) Refrigeration efficiency

   (b) Derive an expression of COP for an air refrigeration system working on reversed Brayton cycle. 8

   (c) Explain the merits and demerits of air refrigeration cycle. 6

2. (a) A regenerative air refrigeration system for an air plane has to take 30 tonne of load, while the ambient conditions are 0.80 bar and 7^0C. 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 compresses air to 50^0C. The cooling air from turbine gets heated to 100^0C before discharging. The isentropic efficiencies of the compressor and the turbine are 90% and 80% respectively. The cabin is pressurised to 1 bar and maintained at 25^0C. Determine the following: 8

   (i) 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.

(b) Explain the vapour compression refrigeration cycle with the help of flow, T-s and p-h diagrams. Can this cycle be reversible? If not, why? Why is the throttle valve not replaced by an isentropic turbine? 6

(c) In a vapour compression refrigeration cycle, discuss the following with the help of sketches (i) effect of suction pressure (ii) effect of condenser pressure (iii) effect of suction vapour superheat (iv) effect of sub cooling. 6

3. (a) Saturated ammonia at 0.2365 MPa enters a 15 cm x 14 cm twin cylinder, simple action compressor whose volumetric efficiency is 79% and speed 250 rpm. The head pressure is 1.1638 MPa. Liquid ammonia at 21^0C enters the expansion valve. For ideal cycle, find (i) ammonia circulated (in kg/min) (ii) refrigerating effect (in tonnes) (iii) COP of the cycle. 8

The extracts from ammonia tables are as follows:

Pressure (MP)	Saturation temperature (^{0}C)	Specific volume of vapour (m^3/kg)	Enthalpy of Liquid (kJ/kg)	Enthalpy of vapour (kJ/kg)	Entropy of liquid (kJ/kgK)	Entropy of vapour (kJ/kgK)
0.2365	-15^0C	0.5106	-831.46	481.52	5.4387	10.526
1.1638	30^0C	0.11084	-620.70	523.42	6.1853	9.9606

Assume specific heat of liquid ammonia as 4.6 kJ/kgK and specific heat of vapour ammonia at constant pressure as 2.75 kJ/kgK.

(b) A Carnot refrigerator requires 1.25 kW per tonne of refrigeration to maintain a region at low temperature of -40^0C. Determine (i) COP (ii) higher temperature of the cycle (iii) heat rejected (in kJ/min) and (iv) COP when this device is used as heat pump. 6

(c) Explain with the flow and p-h diagram, the working of a two stage/compound vapour compression refrigeration cycle with a flash intercooler. Also, derive the expression for mass flow rate of refrigerant and COP of the cycle. 6

4. (a) Consider a two-stage vapour compression refrigeration system operating 8

between the pressure limits of 0.8 and 0.14 MPa. The working fluid, R-134a, leaves the condenser is a saturated liquid and is throttled to a flush chamber operating at 0.32 MPa. Part of the refrigerant evaporates during the flashing process, and this vapour is mixed with the refrigerant leaving the h.p. compressor. The mixture is then compressed to the condenser pressure by the h.p. compressor. The liquid in the flash chamber is throttled to the evaporator pressure and cools the refrigerated space. Assuming the refrigerant leaves the evaporator as a saturated vapour and both compressors are isentropic, draw the flow diagram and determine the (i) fraction of the refrigerant that evaporates as it is throttled to the flash chamber, (ii) amount of heat removed from the space and the compressor work per kg. and (iii) COP. The enthalpies of the refrigerant at various points are determined from R-134a tables and are indicated in the T-s diagram given.

(b) What is an absorption refrigeration cycle? How does it differ from a vapour compressor system? Discuss the relative merits and fields of application of vapour absorption system. 6

(c) Derive the expression for the ideal/maximum COP of an absorption refrigeration system. 6

Group B

5. (a) What are the parameters to be considered in the selection of a refrigerant? Why is the use of the halogenated hydrocarbons as refrigerants now discouraged? Briefly explain the environmental impact of CFC refrigerants. What are the substitutes for CFC refrigerants? 8

(b) Discuss the properties and uses of following refrigerants (i) R-12 (ii) R-22 (iii) NH_3 (iv) CO_2 (v) R-134a. 6

(c) What are the advantages and disadvantages of steam jet refrigeration cycle? 6

6. (a) With the help of psychrometric chart, explain the following processes: 8

(i) sensible cooling

(ii) sensible heating

(iii) cooling and dehumidification

(iv) heating & humidification

(v) chemical dehumidification

(b) Prove that relative humidity, ϕ, is given by 6

$$\phi = \frac{\mu}{1-(1-\mu)(p_{vs} / p_t)}$$

where μ is degree of saturation; p_{vs}, the saturation pressure of vapour in moist air; and p_t, the total pressure of moist air.

(c) Explain the difference between (i) specific humidity and relative humidity (ii) dry bulb temperature (DBT) and wet bulb temperature (WBT). Define dew point temperature (DPT). When do the DBT, WBT and DPT become equal? 6

7. (a) In a laboratory test, a psychrometer recorded a dry bulb temperature of 34^0C and wet bulb temperature of 27^0C. Calculate the following: (i) vapour pressure (ii) relative humidity (iii) degree of saturation (iv) dew point temperature (v) enthalpy of mixture. Given barometric pressure as 1.01325 bar. 8

(b) Explain year round central air-conditioning system with a neat sketch. 6

(c) How can a heat pump is used for waste heat recovery? 6

8. (a) Explain various cooling loads to be considered for air conditioning applications. 8

(b) An air conditioning system is designed under the following conditions: 12

Outdoor conditions = 30^0C DBT and 75% RH

Required indoor conditions = 22^0C DBT and 70% RH

Amount of free air circulated = 3 m^3/sec

Coil dew point temperature = 14^0C

The required condition is achieved first by cooling and dehumidification and then by heating.

Calculate (i) capacity of the cooling coil (in tonnes) (ii) capacity of the heating coil (in kW) (iii) amount of water vapour removed in kg/s.

Group C

9. Answer the following in brief: 20

(i) A Carnot refrigerator requires 70 kJ/min of work to produce one tonne of refrigeration at -40^0C. The C.O.P, of this refrigerator is

(a) 4

(b) 3

(c) 5

(d) Not possible to find.

(ii) Sub-cooling is a process of cooling the refrigerant in vapour compression refrigeration system

(a) after compression.

(b) before compression.

(c) before throttling.

(d) None of the above

(iii) For a given evaporator temperature and given condenser temperature the work input to a compressor having two stages as compared to that having single stage for the same refrigerating capacity is

(a) less.

(b) more.

(c) same.

(d) not predictable.

(iv) Steam jet refrigeration cycle employs the compressor device called

(a) vapour compressor

(b) liquid pump

(c) steam ejector

(d) diffuser

(v) Wet bulb depression is zero, then RH is equal to

(a) 0

(b) 50%

(c) 100%

(d) None of the above.

(vi) There is sensible heat loss from the room and latent heat loss from the room, then room sensible beat factor is

(a) positive.

(b) negative.

(c) mil predictable without actual values.

(d) None of the above.

(vii) If a reversed Carnot cycle has a C.O.P. of 4 for cooling, then ratio of maximum to minimum temperature in the cycle is

(a) 5.0

(b) 1.25

(c) 3.0

(c) 2.0

(viii) In a refrigeration cycle, the heat is rejected by the refrigerant at

(a) evaporator.

(b) condenser.

(c) expansion valve.

(d) compressor.

(ix) The refrigerant used for cooling of aircraft cabin is

(a) air

(b) water

(c) Freon-12

(d) ammonia

(x) Water is used as a refrigerant in

(a) vapour absorption cycle.

(b) cascade system.

(c) steam jet refrigeration.

(d) None of the above.

(Refer our course material for answers)