B.TECH/ME/5TH SEM/MECH 3132/2021

REFRIGERATION & AIR CONDITIONING
(MECH 3132)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) An ideal refrigerant should have (CO1)
(a) low boiling point (b) low freezing point
(c) high latent heat of vapourisation (d) all of these.

(ii) Refrigeration in aeroplanes usually employs the following refrigerant (CO3)
(a) CO_2 (b) Freon-11 (c) Freon-22 (d) Air.

(iii) A system with multiple evaporators at different temperatures with compound compression will: (CO2)
(a) reduce the power requirement,
(b) increase the power requirement,
(c) neither reduce nor increase the power requirement
(d) none of these.

(iv) In closed or dense air refrigeration cycle, the operating pressure ratio can be reduced, which results in .....coefficient of performance (CO3)
(a) lower (b) higher (c) same (d) none.

(v) If room sensible heat is 50kW, room latent heat is 50kW, then the room sensible heat factor is (CO6)
(a) 1 (b) 0.5 (c) 2 (d) 1.5.

(vi) During sensible cooling of air the specific humidity (CO6)
(a) increases (b) decreases
(c) remains constant (d) can't conclude.

(vii) The curved line of psychrometric chart indicates (CO6)
(a) DBT (b) WBT
(c) Specific humidity (d) Relative humidity.

(viii) On a psychromrtric chart, sensible cooling is represent by (CO6)
(a) horizontal line (b) inclined line
(c) vertical line (d) point.

(ix) Vapour absorption refrigeration uses (CO4)
(a) Mechanical energy (b) heat energy
(c) electrical energy (d) all of the above.

(x) Flooding of evaporator happens when (CO4)
(a) refrigeration load decreases
(b) volumetric efficiency of compressor decreases
(c) flow of refrigerant through capillary increases
(b) all of these.

Group – B

2. (a) The machine circulates 4.5 kg ammonia/min. There is no undercooling. The temperature after isentropic compression is 75°C. Find (i) COP of the plant (ii) Ice produced in kg/hr from water at 20° C & ice at -5 °C. (iii) quality of refrigerant entering the compressor. Tale C_{pw}=4.187 kJ/kg-K ,C_{pice} = 2.1 kJ/kg-K, Latent heat of ice 336 kJ/kg ,C_{pgNH3}= 2.82kJ/kg-K. Use the following properties of NH_3. [(CO2) (Evaluate/HOCQ)]

Saturation Temp(°C)	specific enthalpy(kJ/kg)		specific entropy(kJ/kg-K)		specific volume (m^3/kg)	
	h_f	h_g	s_f	s_g	v_f	v_g
-15	112.3	1426	0.457	5.549	0.00152	0.509
30	323.1	1469	1.204	4.984	0.00158	0.111

(b) With the help of T-s diagram, discuss the effect of changing evaporator temperature on the performance of the VCR cycles, keeping the condenser pressure constant. [(CO2)(Understand/LOCQ)]

9 + 3 = 12

3. (a) The following results were obtained in a test conducted on a vapour compression refrigerator:
Evaporator temperature = -28°C, condenser pressure = 2.75 bar, refrigerant entering the condenser is superheated by 3°C, refrigerant leaving the condenser is at 12.8°C.
Determine the C.O.P. of the system. The properties of the refrigerant is given below: [(CO2)(Evaluate/HOCQ)]

Pressure (bar)	Sat. Temp. (°C)	Enthalpy (kJ/kg)		Entropy (vapour) (kJ/kg-K)	Sp. Heat	Sp. Heat
		Liquid	Vapour		Liquid	Vapour
2.75	14	438.48	802.9	5.5287	1.381	0.669
0.412	-28	381.58	783.24	5.6852	-	-

(b) Discuss the effect of variation of suction pressure and discharge pressure on the performance of standard vapour compression refrigeration system with p-h diagram. [(CO2)(Understand/LOCQ)]

8 + 4 = 12

Group – C

4. (a) In aqua ammonia absorption refrigeration system of 12TR capacity. The vapours leaving the generator are 100% pure NH_3 saturated at 36°C. The evaporator, absorber, condenser and generator temperature are -20°C, 26°C, 36°C, 70°C respectively. At absorber exit (strong solution), the concentration of ammonia is solution is x = 0.4 and enthalpy h = 22 kJ/kg. At generator exit weak solution x = 0.09 and h = 690 kJ/kg.
   (i) Determine mass flow rate of ammonia in the evaporator;
   (ii) Carryout overall mass conservation and mass conservation of ammonia in absorber to determine mass flow rates weak and strong solutions. [(CO4)(Evaluate/HOCQ)]

NH_3 thermodynamics property		
	Enthalpy (kJ/kg)	
Temperature(°C)	Saturated Liquid	Saturated vapour
-20°C	89.7	1422.0
26°C	303.6	1468.6
36°C	352.1	1470.8

   (b) Discuss the advantages of vapour absorption refrigeration system over vapour compression refrigeration system. [(CO4) (Analyze/IOCQ)]

10 + 2 = 12

5. (a) An aircraft moving at a speed of 1200 km/h uses a simple gas refrigeration cycle for air-conditioning. The ambient pressure and temperature are 0.36 bar and -11°C respectively. The pressure ratio of the compressor is 5. The heat exchanger effectiveness is 0.95. The isentropic efficiency of compressor and expander are 0.8 each. The cabin pressure and temperature are 1.06 bar and 25°C. Determine temperature and pressure at all point of the cycle. Also find the volume flow rate through compressor inlet and expander outlet for 100TR. [(CO3)(Evaluate/HOCQ)]
   (b) Describe boot-strap air refrigeration cycle with a schematic diagram and show the cycle on the T-S diagram. [(CO3)(Understand/LOCQ)]

10 + 2 = 12

Group – D

6. (a) On what factor the volumetric efficiency of a reciprocating compressor depends? [(CO5)(Analyse/IOCQ)]
   (b) With the help of a neat diagram, explain the flooded evaporator and the Dry-expansion evaporator. [(CO5)(Remember/IOCQ)]

6 + 6 = 12

7. (a) Describe the working principle of an evaporative condenser. [(CO5)(Remember/IOCQ)]
   (b) Explain the term heat rejection factor. [(CO5) (Understand/IOCQ)]

6 + 6 = 12

Group – E

8. (a) 2 kg of air at 20°C, 40% RH is mixed adiabatically with 4 kg of air at 40°C, 40% RH. Find the final condition of the air. [(CO6) (Analyse/IOCQ)]

   (b) The atmospheric air at 25°C DBT and 12°C WBT is flowing at a rate of 100m^3/min through a duct. The dry saturated steam at 100°C is injected into the air stream at a rate of 72kg/hr. Calculate the specific humidity, DBT, WBT, relative humidity and enthalpy of air leaving the duct. [(CO6)(Analyse/HOCQ)]

6 + 6 = 12

9. (a) The following data refer to summer air conditioning of a building
   Outside design conditions = 45°C DBT, 27°C WBT
   Inside design conditions = 23°C DBT, 50%RH
   Room sensible heat gain = 80000 kJ/h
   Room latent heat gain = 19000 kJ/h
   By-pass factor of the cooling coil used = 0.2.
   The return air from the room is mixed with the outside air before entry to the cooling coil in the ratio of 4:1 by mass. Determine (i) Apparatus dew point of the cooling coil (ii) Entry and exit condition of air for cooling coil (iii) Fresh air mass flow rate (iv) Refrigeration load on the coiling load. [(CO6) (Evaluate/HOCQ)]

   (b) What is a psychrometer? [(CO6) (Understand/LOCQ)]

10 + 2 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	17%	33%	50.00%

Course Outcome (CO):

After the completion of the course students will be able to

CO1: Describe the term in refrigeration system and refrigerent used in refrigeration system.
CO2: Analyze standard vapour compression cycle working principle and calculate COP of different systems.
CO3: Understand Air Refrigeration system, its advantages and limitations, and its applications, Aircraft refrigeration system.
CO4: Explain different types of Vapour absorption cycle operates, its advantages and disadvantages over VCRs, Calculate actual COP and theoretical max. COP.
CO5: Justify the use of different components in refrigeration systems.
CO6: Understand various properties of moist air, analyze the various psychrometric processes.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question

Department & Section	Submission link:
ME	https://classroom.google.com/c/NDA2Mjg0NzQ3OTg3?cjc=g4a5rs2