

**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.

NOTE: USE STEAM TABLE / PSYCHROMETRIC CHART / P-H CHART WHEREVER REQUIRE

**Group - A
(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) The highest temperature during the vapour compression refrigeration cycle occurs after
(a) compression (b) condensation
(c) expansion (d) evaporation.
- (ii) Tetrafluoro ethane is the chemical name of which of these refrigerants?
(a) R-12 (b) R 22 (c) R-134a (d) R 11.
- (iii) During vapour compression refrigeration cycle heat is rejected by the refrigerant in
(a) condenser (b) evaporator (c) throttle valve (d) condenser.
- (iv) Flash gas is formed during the _____ process of standard vapour compression refrigeration cycle.
(a) expansion (b) compression
(c) evaporation (d) condensation.
- (v) Bell-coleman cycle is a
(a) Rankine cycle (b) Brayton cycle
(c) Atkinson cycle (d) Ericsson cycle.
- (vi) Work output in expansion process in vapour compression refrigeration cycle is very low because
(a) Sp.vol of refrigerant at the entry of expansion device is low.
(b) Refrigerant is in liquid state before expansion
(c) Refrigerant is at a lower temperature after condensation process
(d) all of these.

- (vii) Component that is not used in vapour absorption refrigeration system is
 - (a) Condenser
 - (b) Evaporator
 - (c) Compressor
 - (d) Throttle valve.
- (viii) DBT, WBT and DPT will be same when the air is
 - (a) unsaturated
 - (b) completely dry
 - (c) they will never be same
 - (d) saturated.
- (ix) Heat rejection Ratio of condenser is given by
 - (a) $HRR = 1 + COP$
 - (b) $HRR = 1 + (1/COP)$
 - (c) $HRR = 1 - COP$
 - (d) $HRR = 1 - (1/COP)$
- (x) Water lithium bromide vapour absorption system is used for achieving refrigeration
 - (a) Temperature $> 0^{\circ}C$
 - (b) Temperature $= 0^{\circ}C$
 - (c) Temperature $< 0^{\circ}C$
 - (d) Any Temperature.

Group - B

2. (a) An ammonia refrigeration system operates between temperature limits of $-15^{\circ}C$ and $30^{\circ}C$. The machine circulates 4.5 kg ammonia /min. There is no under-cooling. The temperature after isentropic compression is $75^{\circ}C$. Find (i) COP of the plant (ii) Ice produced in kg/hr from water at $20^{\circ}C$ & ice at $-5^{\circ}C$. (iii) Quality of refrigerant entering the compressor.
 Take $C_{pw} = 4.187 \text{ kJ/kg-K}$, $C_{pice} = 2.1 \text{ kJ/kg-K}$, Latent heat of ice 336 kJ/kg , $C_{pNH_3} = 2.82 \text{ kJ/kg-K}$.
 Use the following properties of NH_3 .

| Saturation Temp($^{\circ}C$) | 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) According to the international designation of refrigerants, how are the following refrigerants designated? Also write their chemical name.
 (i) $C Cl_3F$ (ii) $C Cl_2 F$ (iii) $C_2F_3Cl_3$ (iv) $C_2F_4Cl_2$
8 + 4 = 12
3. (a) A food storage locker requires a refrigeration capacity of 12 TR and works between the evaporating temperature of $-8^{\circ}C$ and condensing temperature of $30^{\circ}C$. The refrigerant R-12 is sub cooled by $5^{\circ}C$ before entry to expansion valve and the vapour is superheated to $-2^{\circ}C$ before leaving the evaporator coils. Determine: (i) coefficient of performance (ii) theoretical power per tonne of refrigeration.
 Use the following data for R-12

| Saturation Temperature, $^{\circ}C$ | Pressure bar | Enthalpy, kJ/kg | | Enthalpy, kJ/kg K | |
|-------------------------------------|--------------|-----------------|--------|-------------------|--------|
| | | Liquid | Vapour | Liquid | Vapour |
| -8 | 2.354 | 28.72 | 184.07 | 0.1149 | 0.7007 |

| | | | | | |
|----|-------|-------|--------|--------|--------|
| 30 | 7.451 | 64.59 | 199.62 | 0.2400 | 0.6853 |
|----|-------|-------|--------|--------|--------|

The specific heat of liquid R-12 is 1.235 kJ/kg K, and of vapour R-12 is 0.733 kJ/kg K.

- (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.

8 + 4 = 12

Group - C

4. (a) In an absorption type refrigerator, the heat is supplied to NH₃ generator by condensing steam at 3 bar. The temperature in the refrigerator is to be maintained at -4°C. Find the maximum C.O.P possible. If the refrigerator load is 20tonnes and actual C.O.P is 75% of the maximum C.O.P, find the mass of steam required per hour. Take temperature of the atmosphere as 30°C.

- (b) A dense air refrigeration cycle operates between pressure of 3 bar and 12 bar. The air temperature after heat rejection to surroundings is 37°C and air temperature at exit of refrigerator is 7°C. The isentropic efficiency of turbine and compressor are 0.85 and 0.8 respectively. Determine compressor and turbine work per TR and C.O.P of the system.

6 + 6 = 12

5. (a) Draw a neat diagram of three-fluid system of refrigeration and explain its working principle.

- (b) What is the function of the following components in an vapour absorption refrigeration system.

(i) absorber (ii) Heat Exchanger (iii) Analyser.

6 + 6 = 12

Group - D

6. (a) Describe the factors that affect the heat transfer capacity of an evaporator.

- (b) Discuss the operation of capillary tube in refrigeration system. Explain why capillary tube is preferred to other throttling devices in house-hold refrigerator.

6 + 6 = 12

7. (a) Describe with a sketch, a centrifugal compressor. State the advantages and disadvantages of centrifugal compressor over reciprocating compressor.

- (b) Give the comparison of air-cooled condenser and water-cooled condenser.

6 + 6 = 12

Group - E

8. (a) A rectangular duct 0.20 m by 0.15 m is 15 m long and carries standard air at the rate of 0.35 m³/s. Calculate the total pressure required at the inlet to the duct in

order to maintain this flow and the air power. Assume the friction factor $f = 0.005$.

- (b) The reading from a psychrometer are as follows
DBT = 25°C, WBT = 15°C, barometer reading = 745 mm of Hg
Using steam tables, determine (a) Dew point temperature (b) Relative humidity
(c) Degree of saturation.

6 + 6 = 12

9. (a) Air flowing at the rate of 90 m³/min at 35°C dry blub temperature and 50% relative humidity is mixed with another stream another stream flowing at the rate of 20 m³/min at 20°C dry blub temperature and 50% relative humidity. The mixture flows over a cooling whose apparatus due point temperature is 10°C and by-pass factor is 0.2. Find the dry blub temperature and relative humidity of air leaving the coil. If this air is supplied to an air-conditioned room where dry blub temperature of 20°C and relative humidity of 50% are maintained, estimate (1) room sensible heat factor (2) Cooling load capacity of the coil in tones of refrigeration.

- (b) Write a short note of (i) Specific humidity (ii) Relative humidity.

8 + 4 = 12

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