

REFRIGERATION & AIR CONDITIONING
(MECH 3132)

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) What is the primary advantage of a cascade refrigeration system?
(a) It uses only one refrigerant
(b) It is simpler to operate
(c) It can achieve lower temperatures than a single-stage system
(d) It requires less maintenance.
- (ii) If room sensible heat is 45 kW, room latent heat is 55 kW, then the room sensible heat factor is
(a) 0.45 (b) 0.81 (c) 1.22 (d) 2.22.
- (iii) Cooling and dehumidification processes lead to
(a) decrease in temperature and moisture content
(b) increase in temperature and moisture content
(c) decrease in temperature and increase in moisture content
(d) increase in temperature and decrease in moisture content.
- (iv) DBT, WBT and DPT will be same when the air is
(a) unsaturated (b) completely dry
(c) they will never be same (d) saturated.
- (v) On a Psychrometric chart, adiabatic process follows
(a) constant DBT lines (b) constant relative humidity lines
(c) constant DPT lines (d) constant enthalpy lines.
- (vi) In the refrigerant nomenclature R-410A, what do the numbers 410 represent?
(a) Its molecular weight (b) Its flammability rating
(c) Its ozone depletion potential (d) Arbitrary code for identification.
- (vii) Which property of a refrigerant refers to its ability to change from a liquid to a vapor and vice versa at a low temperature?
(a) Latent heat (b) Enthalpy
(c) Sensible heat (d) Heat capacity.

- (viii) The heating of air without addition of moisture is known as
 (a) de-humidification (b) humidification
 (c) the sensible cooling process (d) the sensible heating process.
- (ix) Chemical formula of R 113 refrigerant is
 (a) $C_2Cl_3F_3$ (b) CCl_4
 (c) CCl_2F_2 (d) $CHClF_2$.
- (x) If the C.O.P of 1 TR ammonia-water absorption refrigeration plant is 0.5, then heat supplied in the generator is?
 (a) 1.5 kw (b) 3.5 kW
 (c) 7 kw (d) 10.5 kW.

Fill in the blanks with the correct word

- (xi) The alignment circle is marked on the psychrometric chart at _____.
- (xii) The automatic expansion valve is also known as _____.
- (xiii) In summer air conditioning, the air is _____.
- (xiv) In aqua-ammonia and Li-Br water absorption refrigeration system, the refrigerants are respectively _____.
- (xv) The performance of a vapor compression refrigeration cycle is measured by its _____.

Group - B

2. (a) A food storage plant requires a heat removal capacity of 15 tonnes at an evaporator temperature of $-10^\circ C$ and $30^\circ C$. The refrigerant used is R-12 with the following property table. The refrigerant is subcooled by $8^\circ C$ before entering the expansion valve and is superheated by $9^\circ C$ before leaving the evaporator coil. Assume that the compression of the refrigerant is adiabatic. The compressor specification is: 2 cylinder, single acting, 1000 rpm. Assuming that the volumetric efficiency of the compressor is 80%, and $L=1.2D$ and for R-12, $C_{pl}=1.235$ kJ/kg and $C_{pv}=0.733$ kJ/kg, Calculate
 (i) Mass of refrigerant circulated per minute.
 (ii) Actual piston displacement per minute
 (iii) Actual bore and stroke of the compressor.

Sat. temp ($^\circ C$)	Sp. vol. of vapour (m^3/kg)	Specific enthalpy		Specific entropy	
		$h_f(kJ/kg)$	$h_g(kJ/kg)$	$s_f(kJ/kg-K)$	$s_g(kJ/kg-K)$
$-10^\circ C$	0.0767	26.9	183.2	0.1080	0.7020
$30^\circ C$	0.0235	64.6	199.6	0.2399	0.6854

[[CO3](Analyse/HOCQ)]

- (b) Write short notes on (i) ODP (ii) GWP.

[[CO2](Understand/LOCQ)]

8 + 4 = 12

3. (a) A simple Refrigerant 134a (Tetrafluoro-ethane) heat pump for space heating operates between the temperature limits of $15^\circ C$ and $50^\circ C$. The heat required to be pumped is 100 MJ/h. Determine: (i) the dryness fraction of refrigerant

entering the evaporator, (ii) the discharge temperature assuming the specific heat of vapour as 0.996 kJ/(kg-K), (iii) the theoretical piston displacement of the compressor, (iv) the theoretical horsepower of the compressor, and (v) the COP. The specific volume of Refrigerant 134a saturated vapour at 0.04185 m³/kg. The other relevant properties of R134a are given below:

Temp., °C	Enthalpy (kJ/kg)		Entropy (kJ/kg-K)	
	Liquid	Vapour	Liquid	Vapour
15	220.48	417.1	1.0725	1.72
50	271.62	423.4	1.24	1.7072

[[CO2](Create/HOCQ)]

- (b) With the help of a schematic diagram, explain the working principle of cascade refrigerating system and its advantages and disadvantages. [[CO2](Remember/LOCQ)]

8 + 4 = 12

Group - C

4. (a) A dense air refrigeration cycle operates between pressure of 4 bar and 16 bar. The air temperature after heat rejection to surroundings is 36°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 (i) compressor and turbine work per TR, (ii) C.O.P and (iii) power per TR. [[CO3](Analyse/IOCQ)]

- (b) State the difference between open air refrigeration cycle and closed air refrigeration cycle. [[CO3](Apply/IOCQ)]

8 + 4 = 12

5. (a) Explain with diagram the working of a simple air cycle cooling system used for aircrafts. Draw T-s diagram for the system. [[CO3](Understand/LOCQ)]

- (b) Compare briefly Vapour Compression Refrigeration Cycle with Vapour Absorption Refrigeration Cycle. [[CO4](Remember/LOCQ)]

8 + 4 = 12

Group - D

6. (a) With the help of a typical characteristic curve, describe “surging” and “choking” in a centrifugal compressor. [[CO5](Analyse/IOCQ)]

- (b) What are the factors affects the heat transfer capacity of an evaporator? [[CO5](Remember/LOCQ)]

6 + 6 = 12

7. (a) Draw a neat sketch of a constant pressure expansion valve. Explain its working principle. [[CO5](Remember/LOCQ)]

- (b) With the help of a neat diagram, explain the flooded evaporator and the dry expansion evaporator. [[CO5](Remember/LOCQ)]

6 + 6 = 12

Group - E

8. (a) The atmospheric air at 760 mm of Hg, dry bulb temperature 15°C and wet bulb temperature 11°C enters a heating coil whose temperature is 41°C. Assuming by-pass factor of heating coil as 0.5, determine dry bulb temperature and relative humidity of the air leaving the coil. Also determine the sensible heat added to the air per kg of dry air. [[CO6](Analyse/IOCQ)]
- (b) Write short notes on (i) by-pass factor of cooling coil (ii) Relative humidity (iii) Dew point temperature. [[CO6](Remember/LOCQ)]

6 + 6 = 12

9. A retail shop located in a city at 30°N latitude has the following loads:
Room sensible load : 58 kW
Room latent Heat : 14 kW. The summer outside and inside design conditions are; Inside : 25°C DBT, 50% RH
Outside : 40°C DBT, 27°C WBT
The amount of ventilation air used is 70 m³/min of ventilation air is used. Determine the following: (i) Ventilation load, (ii) Grand total heat, (iii) Effective sensible heat factor, (iv) Apparatus dew point, (v) Dehumidified air quantity, (vi) Condition of air entering and leaving the apparatus. Assume a suitable bypass factor of the cooling coil as 0.15. [[CO6](Create/HOCQ)]

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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	45.8	25	29.2

Course Outcome (CO):

After the completion of the course students will be able to:

- CO1 Describe the term in the refrigeration system and various refrigerants used in the refrigeration system and its impact on the environment.
- CO2 Analyze standard vapour compression cycle working principle and calculate COP of different systems.
- CO3 Explain Air Refrigeration system, its advantages and limitations, and its applications, Aircraft refrigeration system.
- CO4 Judge the different parts of vapour absorption refrigeration cycle, its advantages and disadvantages over VCRS.
- CO5 Recognize the use of different components in refrigeration systems.
- CO6 Calculate various properties of moist air, evaluate the various psychrometric processes.

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