

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) Which property of a refrigerant refers to its ability to change from a liquid to a vapour and vice versa at a low temperature?
(a) Latent heat (b) Enthalpy
(c) Sensible heat (d) Heat capacity.
- (ii) The highest temperature during the vapour compression refrigeration cycle occurs after
(a) compression (b) condensation
(c) expansion (d) evaporation.
- (iii) In a vapour absorption refrigeration cycle, the driver of the cycle is
(a) Boiler (b) Turbine
(c) Compressor (d) Pump.
- (iv) In the gas cycle refrigeration system, the throttle valve of a vapour compression refrigerant system is replaced by
(a) Capillary tube (b) Expander
(c) Reverse throttle valve (d) Absorber and pump
- (v) A boot strap air cooling system has
(a) One heat exchanger (b) Two heat exchanger
(c) Three heat exchanger (d) Four heat exchanger
- (vi) Which of the following components is common between vapour compression and vapour absorption refrigeration system?
(a) Condenser (b) Absorber
(c) Generator (d) Rectifier.
- (vii) The evaporator used in house hold refrigerator is
(a) Frosting evaporator (b) Non-frosting evaporator
(c) Defrosting evaporator (d) None of these

- (viii) The pressure in capillary tube decreases due to
 (a) Frictional resistance offered by tube wall
 (b) Acceleration of refrigerant in the tube
 (c) Heat transfer from the tube
 (d) Both (a) and (b).
- (ix) The ambient temperature recorded by an ordinary thermometer is known as
 (a) Wet Bulb Temperature (b) Dew Point Temperature
 (c) Dry Bulb Temperature (d) Saturated Temperature.
- (x) During sensible heating of air the specific humidity
 (a) Increases (b) Decreases
 (c) Remains constant (d) Can't conclude.

Fill in the blanks with the correct word

- (xi) Thermostatic expansion valve operates on the change in the _____.
- (xii) In aqua-ammonia and Li-Br water absorption refrigeration system, the refrigerants are respectively _____.
- (xiii) Wet bulb depression is zero, when relative humidity is equal to _____.
- (xiv) The bare tube evaporators are also known as _____ evaporators.
- (xv) DBT, WBT and DPT will be same when the air is _____.

Group - B

2. (a) A refrigeration cycle uses Freon-12 as the working fluid. The temperature of the refrigerant in the evaporator is -10°C . The condensing temperature is 40°C . The cooling load is 150 W and the volumetric efficiency of the compressor is 80%. The speed of the compressor is 720 r.p.m. Calculate the mass flow rate of the refrigerant and the displacement volume of the compressor.

Properties of Freon-12:

Temperature ($^{\circ}\text{C}$)	Saturation Pressure (MPa)	Enthalpy(kJ / kg)		Specific Volume (m^3/kg) Saturated vapour
		Liquid	Vapour	
-10	0.22	26.8	183.0	0.08
40	0.96	74.5	203.1	0.02

[[CO2](Apply/10CQ)]

- (b) Sketch the T-s and p-h diagrams for the vapour compression cycles when the vapour after compression is (i) dry saturated (ii) wet.

[[CO1](Understand/LOCQ)]

4 + 8 = 12

3. (a) The following data relate to an air-conditioner working on the reversed Carnot cycle: Capacity = 2 tonnes; Temperature of heat absorption in cooling coil heat exchanger = 5°C ; Temperature of heat rejection of condenser heat exchanger = 60°C ; Temperature of air entering heat rejection heat exchanger = 40°C ; Temperature of air leaving heat rejection exchanger = 50°C ; Overall heat transfer coefficient of heat rejection of heat exchanger between air and working substance

in the cycle = $800 \text{ kJ/h-m}^2\text{-K}$ Determine: (i) Co-efficient of performance (ii) Work input to the air-conditioner (iii) Mass flow rate of entering air; and (iv) Area of heat exchanger. [[CO2](Apply/IOCQ)]

- (b) A certain machine works on reversed Carnot cycle between temperature limits of (-10°C) and 27°C . Find its C. O. P., when working as (i) a refrigerating machine, (ii) a heat pump and (iii) a heat engine? [[CO1](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 temperatures 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 $h = 22 \text{ kJ/kg}$. At generator exit, the corresponding parameters for the weak solution are $x = 0.09$ and $h = 695 \text{ kJ/kg}$. (i) Determine mass flow rate of ammonia in the evaporator; (ii) Determine the mass flow rates of weak and strong solutions in the absorber.

NH_3 thermodynamic properties		
Temperature($^\circ\text{C}$)	Enthalpy(kJ/kg)	
	Saturated Liquid	Saturated vapour
-20°C	89.7	1419.0
26°C	303.6	1465.6
36°C	352.1	1470.8

[[CO4](Evaluate/HOCQ)]

- (b) Discuss the advantages and disadvantages of the Air refrigeration system over the vapour compression refrigeration system. [[CO3](Remember/LOCQ)]

8 + 4 = 12

5. An aircraft 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 -10°C respectively. The pressure ratio of compressor is 4.5. 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 points of the cycle. Also find the volume flow rate through the compressor inlet and the expander outlet for 100TR. [[CO3](Evaluate/HOCQ)]

12

Group - D

6. (a) Describe a centrifugal compressor with a sketch. [[CO5](Remember/LOCQ)]
 (b) Explain the dry expansion evaporator with the help of a neat sketch. [[CO5](Remember/LOCQ)]

6 + 6 = 12

7. (a) Give the comparison of air cooled condenser and water cooled condenser. [[CO5](Remember/LOCQ)]

- (b) Draw a neat sketch of a constant pressure expansion valve. Explain its working principle.

[[CO5] (Remember/LOCQ)]

6 + 6 = 12

Group - E

8. In an air-conditioning system, the inside and outside conditions are dry bulb temperature (DBT) 25°C, relative humidity 50% and DBT 40°C, wet bulb temperature 27°C respectively. The room sensible heat factor is 0.8. 50% of the room air is rejected to atmosphere and an equal quantity of fresh air is added before air enters the air conditioning apparatus. If the fresh air is 100m³/min, determine: (i) Room sensible and latent heat load (ii) Sensible and latent heat load due to fresh air (iii) Apparatus dew point (iv) Humidity ratio and DBT of air entering air conditioning apparatus. Assume the by-pass factor as zero, air density 1.2 kg/m³ at a total pressure of 1.01325 bar.

[[CO6] (Evaluate/HOCQ)]

12

9. Derive an expression for the equivalent diameter of circular duct corresponding to a rectangular duct of sides a and b, for the same pressure loss per unit length, when (i) the quantity of air passing through both the ducts is same, and (ii) the velocity of air flowing through both the ducts is same. The friction factor remains the same for both the ducts.

[[CO6] (Apply/IOCQ)]

(8 + 4) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	41.67	25	33.33