

CS/B.Tech/ME/Even/Sem-6th/ME-604A/2015

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WEST BENGAL UNIVERSITY OF TECHNOLOGY

ME-604A

AIRCONDITIONING AND REFRIGERATION

Time Allotted: 3 Hours

Full Marks: 70

The questions are of equal value.

The figures in the margin indicate full marks.

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

GROUP A

(Multiple Choice Type Questions)

10×1 = 10

1. Answer all questions.

(i) A good refrigerant should have

- (A) low specific heat ratio (γ) (B) high thermal conductivity
(C) high latent heat (D) all of these

(ii) In aqua ammonia absorption system, incomplete rectification leads to accumulation of water in

- (A) evaporator (B) absorber (C) condenser (D) all of these

(iii) For the same frictional loss in the air conditioning duct of round cross-section and rectangular cross-section, the equivalent round duct dia is (a = width of duct, b = breadth of duct)

- (A) $d_e = \frac{2ab}{a+b}$ (B) $d_e = \frac{ab}{a+b}$ (C) $d_e = \frac{a+b}{2ab}$ (D) $d_e = \frac{a+b}{ab}$

(iv) Specific humidity (W) of moist air with P_v as partial pressure of water vapour is related as

- (A) $W = 0.622 \frac{P}{P - P_v}$ (B) $W = 0.622 \frac{P_v}{P - P_v}$

- (C) $W = 0.622 \frac{P}{P - P_a}$ (D) $W = 0.622 \frac{P_a}{P - P_v}$

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- (v) Natural convection air cooled condensers are used for
(A) domestic refrigerator (B) domestic air conditioner
(C) both (A) and (B) (D) none of these

(vi) Compound compression is adopted for refrigeration system

- (A) to improve volumetric efficiency
(B) to reduce mechanical work input unit mass
(C) to take care of very large pressure ratios
(D) to achieve all of these

(vii) The effect of liquid sub-cooling in vapour compression refrigeration system is

- (A) to reduce the refrigerant flow rate per ton of refrigeration
(B) to reduce the volume of vapour handled by compressor per ton of refrigeration
(C) to reduce the power per ton of refrigeration
(D) all of the above

(viii) While designing the refrigeration system of an aircraft prime consideration is that the

- (A) weight of refrigerant circulated in the system is low
(B) weight of the refrigeration equipment is low
(C) system has high COP
(D) work consumption per ton of refrigeration is low.

(ix) In an unsaturated air, the state of vapour is

- (A) wet (B) superheated (C) dry saturated (D) subcooled

(x) Air at dry bulb temperature of 30°C and a dew point temperature of 19°C is passed over a cooling coil maintained at 24°C. The process will be

- (A) sensible cooling (B) cooling and dehumidification
(C) cooling and humidification (D) dehumidification

GROUP B

(Short Answer Type Questions)

Answer any three questions.

3×5 = 15

2. What is by-pass factor? Explain the procedure to draw GSHF line on a psychrometric chart.

5

3. (a) Define relative humidity (ϕ) and degree of saturation (μ).

2

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

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$$(\phi) = \frac{\mu}{1 - (1 - \mu) \frac{P_{vs}}{P_t}}$$

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Where, μ = degree of saturation, P_{vs} = saturation pressure of vapour in moist air and P_t = total pressure of moist air.

4. What is the significance of ventilation? Briefly describe 'Supply Of Pressure' system with suitable diagram. 2+3
5. Prove that the equivalent diameter for circular duct to replace rectangular duct for the same volume rate of air is $D_e = 1.265 \left(\frac{a^3 b^3}{a+b} \right)^{1/5}$; where D_e = equivalent diameter for round duct, a = width of rectangular duct, b = breadth of rectangular duct. 5
6. At a particular time on a day the dry bulb temperature is 37°C, the relative humidity is 50% and the barometric pressure is 101.325 kPa. Calculate the specific humidity, dew point temperature and enthalpy of moist air. 5

GROUP C

(Long Answer Type Questions)

Answer any three questions.

3×15 = 45

7. A refrigeration unit works between an evaporator temperature of -15°C and a condenser saturation temperature of 35°C with R-12 as refrigerant.
 - (a) Determine the COP if it operates on standard saturation cycle.
 - (b) Determine COP if subcooling and superheating are achieved by installing a liquid-vapour heat exchanger with the vapour leaving the heat exchanger at 15°C.

Properties of R-12

| Saturation temp. °C | Pressure MPa | h_f kJ/kg | h_g kJ/kg | s_g kJ/kgK | Degree of superheat | | | |
|---------------------|--------------|-------------|-------------|--------------|---------------------|------------|-----------|------------|
| | | | | | 20 K | | 40 K | |
| | | | | | h kJ/kg | s kJ/kgK | h kJ/kg | s kJ/kgK |
| 35 | 0.8477 | 69.5 | 201.3 | 0.6834 | 216.4 | 0.731 | 231.0 | 0.7741 |
| -15 | 0.1826 | 22.3 | 181.0 | 0.7046 | 193.2 | 0.751 | 205.7 | 0.7942 |

8. (a) An air refrigeration plant of 20 ton capacity comprises a centrifugal compressor, a cooler heat exchanger and an air turbine. The compressor is coupled to the air turbine directly. The processes in the compressor and the turbines are adiabatic but not isentropic. Air at temperature 21°C and 0.85 bar enters the compressor. It leaves the compressor at 90°C. The same air enters the turbine 38°C and 1.5 bar. The turbine exit is at 0°C. Assuming no pressure drop in the cooler and the refrigerator section, and $C_p = 1.004$ kJ/kgK and $C_v = 0.712$ kJ/kgK, determine
 - (i) Compressor efficiency

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- (ii) Turbine efficiency
- (iii) The flow rate of air
- (iv) The power input of the plant
- (v) COP.
- (b) What is "heat rejection factor" for a condenser? 2
- (c) Differentiate between natural draft cooling tower and mechanical draft cooling tower. 3
9. (a) In an absorption type refrigerator, heat is supplied to NH_3 generator by condensing steam at 2 bar and 88% dry. The temperature in the refrigerator is to be maintained at -4°C. If the refrigeration load is 18 ton and actual COP is 72% of maximum COP, calculate:
 - (i) the maximum COP possible and actual COP
 - (ii) Mass of steam required per hour.
 You may take the condensing temperature as 35°C.
- (b) Name any two methods for determination of air conditioning duct size and briefly state their respective principle. State one advantage and one disadvantage of each method. 6
10. (a) Write down the merits and demerits of an air refrigeration system 4
- (b) Draw the schematic of Bell Coleman refrigerator and explain its working principles with p-V and T-s diagrams. 5
- (c) 500 kg atmospheric air is circulated per hour in an open type refrigeration installation. The air from the cold chamber at temperature 8°C and 1 bar, then compressed isentropically to 5 bar absolute. It is cooled at this pressure to 28°C and then led to the expander for isentropic expansion down to atmospheric pressure to cold chamber. Determine,
 - (i) heat rejected from cold chamber per hour
 - (ii) heat rejected to cooling water per hour
 - (iii) COP of the system
11. (a) Sketch an induced draft cooling tower and show its operation.
- (b) An air-conditioned auditorium is to be maintained at 27°C DBT and 55% RH. The ambient condition is 39°C DBT and 28°C WBT. The total sensible heat load is 120,000 kJ/h and the total latent heat load is 45,000 kJ/h, 60% of the return air is recirculated and mixed with 40% of the make-up air after the cooling coil. The condition of air leaving the coil is 17°C. Determine
 - (i) room sensible heat factor
 - (ii) condition of air entering the auditorium
 - (iii) amount of make-up air
 - (iv) apparatus dew point
 - (v) by-pass factor of the cooling coil.