Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.Tech (ME)/SEM-8/ME-815/2010

2010

REFRIGERATION AND AIR-CONDITIONING

Time Allotted : 3 Hours *Full Marks :* 70

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)

1. Choose the correct alternatives for the following : 10 × 1 = 10

   i) A one tonne of refrigerating machine means that

      a) the total weight of the machine is one ton

      b) the quantity of the refrigerant used is one ton

      c) one ton of water can be converted into ice

      d) one tonne of ice when melts from and at 0° C in 24 hours, the refrigerating effect is equivalent to 14000 kJ/hour.

   ii) Which of the following properties of a refrigerant is undesirable ?

      a) High critical temperature

      b) Low specific heat of liquid

      c) Low specific volume of vapour

      d) High boiling point.

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iii) The refrigerant *R*-744 stands for

a) Ammonia

b) Carbon dioxide

c) Sulphur dioxide

d) Methyl chloride.

iv) Room sensible Heat = 50 kW, Room latent heat = 25 kW. Then room sensible heat factor is

a) 0·50 b) 0·67

c) 0·75 d) 0·33

v) If by-pass factor of each depth is 0·8, the combined by-pass factor of a 4-depth coil is

a) 0·41 b) 0·95

c) 0·62 d) 0·8.

vi) For rectangular ducts, the aspect ratio is equal to

a) sum of longer & shorter sides

b) difference of longer & shorter sides

c) product of longer & shorter sides

d) ratio of longer & shorter sides.

vii) When the quantity of air passing through the rectangular duct and circular duct is same, then the equivalent dia $\left(D_{eq}\right)$ of a circular duct for a rectangular duct for the same pressure loss per unit length, is given by

a) $1{\cdot}265\left(\frac{a^3 b^3}{a+b}\right)^{\frac{1}{5}}$ b) $1{\cdot}265\left(\frac{a^4 b^4}{a+b}\right)^{\frac{1}{5}}$

c) $1{\cdot}265\left(\frac{a+b}{a^3 b^3}\right)^{\frac{1}{5}}$ d) $1{\cdot}265\left(\frac{a+b}{a^4 b^4}\right)^{\frac{1}{5}}$.

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viii) COP of a vapour absorption system as compared to that of a vapour compression system is

a) more

b) less

c) unpredictable

d) less for sub-zero temperature and more for temperature above zero.

ix) In a vapur absorption refrigeration system heating in generator is done at 100° C, refrigeration in evaporator at 10° C and cooling by cooling water in condenser at 30° C. The maximum COP is

a) 0·38

b) 0·42

c) 0·56

d) none of these.

x) Thermostatic expansion valve operates on

a) the changes in temperature in the evaporator

b) the changes in pressure in the evaporator

c) the changes in degree of superheat at exit from the evaporator

d) none of these.

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GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. What do you mean by adiabatic saturation temperature ? Derive the expression of the sigma function from the heat balance during adiabatic saturation.

3. Prove that relative humidity, ϕ is given by

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

where, μ = Degree of saturation,

P_{vs} = Saturation pressure of vapour in moist air,

P_t = total pressure of moist air.

4. Prove that the equivalent diameter for circular duct to replace rectangular duct for the same volume rate of flow of air is

$$D_e = 1{\cdot}265\left(\frac{a^3 b^3}{a+b}\right)^{\frac{1}{5}}$$

where, D_e = equivalent diameter for round duct

a = width of rectangular duct

b = breadth of rectangular duct

5. Show that the COP of an n-stage cascade refrigeration system is given by

$$\text{COP}_{n-stage} = \frac{1}{\left(1+1/\text{COP}^{I}\right)^{n}-1}$$

where, COP^{I} is the coefficient of performance of each stage.

6. Explain any two methods of capacity control in a reciprocating compressor.

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GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Make a comparative study of vapour compression and vapour absorption refrigeration system. 5

   b) A vapour absorption system works with

   Generator temperature = 87° C;

   Absorber temperature = 37° C;

   Evaporator temperature = – 13° C;

   Obtain the COP of the system. If the evaporator temperature falls to – 18° C, what should be the generator temperature in order to operate the system with the same COP ? 10

8. a) Derive an expression for the equivalent dia. of circular duct corresponding to a rectangular duct of sides *a* and *b* for the same pressure loss per unit length when the velocity of air flowing through both the ducts is the same. 5

   b) Explain static regain method of duct design for air conditioning. 3

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c) A 30 m long rectangular duct, 20 mm × 160 mm in size, carries standard air at the rate of 24 m^3/min. Assuming the friction factor f = 0·0048, determine :

i) total pressure required at the inlet to the duct to maintain this flow; and

ii) air power required. 7

9. a) Derive an expression of equivalent resistance for n number of duct systems connected in parallel. 3

b) The loss of pressure in a sudden enlargement of duct is assumed as

$$P_l = \rho \frac{(v_1 - v_2)^2}{2}$$

where, v_1 = velocity in smaller duct

v_2 = velocity in larger duct

ρ = fluid density.

Show that in a gradual expander the static pressure downstream is always greater than the static pressure upstream and also that the minimum static regain possible is given by

$$SR = \frac{2\lambda}{1+\lambda}$$

where λ is the area ratio A_1/A_2. 12

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10. a) What are the advantages and disadvantages of vapour compression refrigeration system ? 4

b) Prove that for a Carnot vapour compression refrigeration system

$COP = T_e/(T_c - T_e)$

where, T_e = Evaporator temperature and

T_c = Condenser temperature. 5

c) A Freon – 12 vapour compression refrigeration system, operating at a condenser temperature of 40° C and an evaporator temperature of 0° C, develops 15 tons of refrigeration. The refrigerant is saturated at the entry to the compressor and take specific heat of vapour as 0·674 kJ/kg-K. Draw the $p - h$ and T-s diagrams of the cycle and determine the following :

i) the discharge temperature of the refrigerant

ii) mass flow rate of refrigerant circulated

iii) Carnot COP and actual COP of the cycle.

The properties of Freon – 12 are as always :

	h_f (kJ/kg)	h_g (kJ/kg)	S_g (kJ/kg-K)	v_g (m^3/kg)
0° C	—	187·5	0·6966	0·0554
40° C	74·6	203·2	0·6825	—

Symbols have their own meanings. 6

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11. It is required to maintain an air conditioned hall at 28° C DBT and 20° C WBT. It has sensible heat load of 45·4 kW and latent heat load of 16·5 kW. The air supplied from outside atmosphere at 39° C DBT and 28° C WBT is 22 m^3/min, directly into the room through ventilation and infiltration. Outside air to be conditioned is passed through the cooling coil whose apparatus dew point is 14° C, 60% of the recirculated air from the hall is mixed with the conditioned air after the cooling coil. Determine :

i) condition of air after the coil and before the recirculated air mixes with it.

ii) condition of air entering the hall *i.e.*, after mixing with recirculated air.

iii) mass of fresh air entering the cooler.

iv) by-pass factor of cooling coil.

v) refrigerating load on the cooling coil.

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