53 (FPT 713) RFAC

2013

(December)

REFRIGERATION AND AIR-CONDITIONING

Paper : FPT 713

Full Marks : 100

Time : Three hours

***The figures in the margin indicate full marks
for the questions.***

*Answer **any five** questions **out of seven**.*

"Use of Refrigerant Tables and Psychrometric
Charts Book is permitted."

1. *(a)* What do you mean by "Ton of
    Refrigeration" ? Write the characteristics
    of all heat engines.   2+2=4

    (b) What is a refrigerator ? Explain briefly the
    working principle of a refrigerator with
    schematic diagram. Define the coefficient of
    performance of it.   2+4+2=8

(c) A household refrigerator with a *C.O.P* of 1.2 removes heat from the refrigerated space at a rate of 60*kJ/min*. Determine

    (i) The electric power consumed by the refrigerator

    (ii) The rate of heat transfer to the kitchen air.   4

(d) Determine the *C.O.P* of a refrigerator that removes heat from the food compartment at a rate of 5040 *kJ/h* for each *kW* of power it consumes.

Also, determine the rate of heat rejection to the outside air.   4

2. (a) What is the main objective of a heat pump ? Define coefficient of performance of a heat pump. Can it be greater than unity ?   1+2+1=4

(b) A heat pump is used to maintain a house at a constant temperature of $23^{\circ}C$. The house is losing heat to the outside air through the walls and windows at a rate of 60,000 kJ/h while the energy generated within the house from people, lights and appliances amount to $4000kJ/h$. For a C.O.P. of 2.5, determine the required power input to the heat pump. 3

(c) Mention the *four* main processes of reversed Carnot refrigerator. Explain the working principle of the reversed Carnot refrigeration cycle with schematic diagram. 2+6=8

(d) A Carnot refrigerator operates in a room in which the temperature is $25^{\circ}C$. The refrigerator consumes $500W$ of power when operating and has a *C.O.P.* of 4.5.

Determine –

(i) The rate of heat removed from the refrigerated space and

(ii) The temperature of the refrigerated space. 5

3. (a) What is an ideal vapour compression refrigeration (VCR) cycle ? Explain briefly the effects of operating conditions in VCR cycle. 2+6=8

(b) Refrigerant 134a is the working fluid in an ideal vapour-compression refrigeration cycle that communicates thermally with a cold region at $0°C$ and a warm region at $26°C$. Saturated vapour enters the compressor at $0°C$ and saturated liquid leaves the condenser at $26°C$. The mass flow rate of the refrigerant is 0.08 kg/s. Determine –

(a) The compressor power, in kW

(b) The refrigerating capacity, in tons

(c) The coefficient of performance and

(d) The coefficient of performance of a Carnot refrigeration cycle operating between warm and cold regions at $26°C$ and $0°C$ respectively. 12

4. *(a)* Explain briefly the "Cascade Refrigeration".

5

(b) Consider a two-stage cascade refrigeration system operating between the pressure limits of 0.8 *MPa* and 0.14 *MPa*. Each stage operates on the ideal vapour compression refrigeration cycle with refrigerant-134*a* as the working fluid. Heat rejection from the lower cycle to the upper cycle takes place in an adiabatic counterflow heat exchanger where both streams enter at about 0.4 *MPa*. If mass flow rate of the refrigerant through the upper cycle is 0.24 *kg/S*, determine –

(a) The mass flow rate of the refrigerant through the lower cycle.

(b) The rate of heat removal from the refrigerated space.

(c) The power input to the compressor.

(d) The coefficient of performance of this cascade refrigerator.

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5. (a) Define *any five* of the following : 2×5=10

     (i) Dew point temperature

     (ii) Specific humidity

     (iii) Relative humidity

     (iv) Wet-bulb temperature

     (v) Dry bulb temperature

     (vi) Moist air.

(b) Prove that the relation between the degree of saturation (μ) and relative humidity (ϕ) is given by an expression :   10

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

where, p = Total pressure

             P_{vs} = Saturation vapour pressure

6. (a) Explain briefly the basic features of the psychrometric chart with a schematic diagram.

(b) If the relative humidity of air and temperature of a room are known to you, then how will you determine the following properties by using psychrometric chart : 5

    (i) Specific humidity

    (ii) Enthalpy

    (iii) Wet bulb temperature

    (iv) Dew point temperature

    (v) Specific volume of air.

(c) The air in a room is at 1 *atm*, 32°C and 60% relative humidity. Determine the following using the 'psychrometric chart' – 5

    (i) Specific humidity

    (ii) Enthalpy (in *kJ/kg* dry air)

    (iii) Wet-bulb temperature

    (iv) Dew point temperature

    (v) Specific volume of air.

(d) The DBT and WBT of atmospheric air are 35°C and 23°C respectively when the barometer reads 75cm of Hg. Using 'psychrometric table', calculate the following if partial pressure of water vapour is 15.18mm of Hg :   5

    (i) Relative humidity

    (ii) Humidity Ratio

    (iii) Dew point temperature.

7. Write short notes on **any four** of the following :
                                         4×5=20

    (a) Designation of Refrigerant

    (b) Vapour absorption Refrigeration System

    (c) Air washer

    (d) Simple air-conditioning system

    (e) Cooling with dehumidification.

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