

B.Tech 7th Semester Exam., 2020

REFRIGERATION AND AIR-CONDITIONING

Time : 3 hours

Full Marks : 70

Instructions :

- (i) The marks are indicated in the right-hand margin.
- (ii) There are **NINE** questions in this paper.
- (iii) Attempt **FIVE** questions in all.
- (iv) Question No. 1 is compulsory.
- (v) Use of Steam table, Refrigerant table and Psychrometric chart is allowed.

1. Choose the correct answer of the following

(any seven) : $2 \times 7 = 14$

- (a) In a vapour compression refrigeration cycle for making ice, the condensing temperature for higher COP
 - (i) should be near the critical temperature of the refrigerant
 - (ii) should be above the critical temperature of the refrigerant
 - ~~(iii) should be much below the critical temperature of the refrigerant~~
 - (iv) could be of any value as it does not affect the COP

(b) HCFCs have

- (i) zero ODP
- (ii) high ODP
- (iii) low ODP and low GWP
- (iv) low ODP and high GWP

(c) The critical temperature of CO_2 is

- (i) 73 °C
- (ii) 37 °C
- (iii) 13 °C
- ~~(iv) 31 °C~~

(d) Moisture choking is a frequent problem with

- (i) R22 as a refrigerant
- (ii) R134a as a refrigerant
- ~~(iii) NH_3 as a refrigerant~~
- (iv) R600a as a refrigerant

(e) In conventional refrigerants, what is the element responsible for ozone depletion?

~~(i) Chlorine~~

(ii) Fluorine

(iii) Carbon

(iv) Hydrogen

(f) To fix the state point in respect of air-vapour mixtures, three intrinsic properties are needed. Yet, the psychrometric chart requires only two because

(i) the water vapour is in the superheated state

~~(ii) the chart is for a given pressure~~

(iii) the chart is an approximation to true values

(iv) the mixtures can be treated as a perfect gas

(g) Which of the following are normally desired comfort conditions in an air-conditioning system?

(i) 25 °C DBT and 50% RH

(ii) 15 °C DBT and 75% RH

~~(iii) 22 °C DBT and 90% RH~~

(iv) 15 °C DBT and 40% RH

(h) In the case of a cooling coil with non-zero bypass factor, the apparatus dew point temperature lies at the intersection point of

(i) room DBT line with the saturation curve

(ii) RSHF and GSHF lines

(iii) RSHF and ESHF lines

(iv) GSHF line with the saturation curve

(i) A cooling coil with a bypass factor of 0.1 and apparatus dew point (ADP) of 12 °C comes in contact with air having

a dry-bulb temperature of 38 °C and dew point of 9 °C. Over the cooling coil, the air would undergo

- (i) sensible cooling
- (ii) cooling and dehumidification
- (iii) cooling and humidification
- (iv) adiabatic saturation

(j) During chemical dehumidification process of air

- (i) dry-bulb temperature and specific humidity decrease
- (ii) dry-bulb temperature increases and specific humidity decreases
- (iii) dry-bulb temperature decreases and specific humidity increases
- (iv) dry-bulb temperature and specific humidity increase

2. (a) (i) List out the advantages of vapour refrigeration system over air-refrigeration system.

(ii) The ambient temperature and pressure at around 10000 m, where an air-plane cruises are approximately -50 °C and 0.15 bar, respectively. Yet, a refrigeration system is required for cooling of the air-planes. Explain the reasons. 7

(b) A refrigerator working on the Bell-Coleman cycle operates between pressure limits of 1.05 bar and 8.5 bar. Air is drawn from the cold chamber at 10 °C, compressed and then it is cooled to 30 °C before entering the expansion cylinder. The expansion and compression follow the law $p\nu^{1.3} = \text{constant}$. Determine the theoretical COP of the system. 7

3. (a) A domestic refrigerator uses R134a as refrigerant and operates between evaporator and condenser temperatures of -25 °C and 50 °C. After leaving the condenser, the liquid refrigerant is further sub-cooled in a regenerative heat exchanger in which the vapour from the evaporator is heated to 30 °C.

The compressor displacement volume is 4.33 cm^3 . Using the $p-h$ diagram of R134a, calculate the refrigerating capacity and power consumption of the refrigerator. Consider the volumetric efficiency of the compressor to be 0.68, and its adiabatic efficiency to be 0.85. Also find the compressor discharge temperature. The compressor is directly coupled to a motor running at 2900 r.p.m.

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(b) Explain the importance of the following thermodynamic properties in selecting a refrigerant for a particular application :

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- (i) Normal boiling point
- (ii) Critical temperature and pressure
- (iii) Freezing point

4. The following data were collected to design an air-conditioning system of a hall :

Outside design conditions : 38°C DBT and 28°C WBT

Inside design conditions : 24°C DBT and 60% RH

Sensible heat load : 160000 kJ/hr

Latent heat load : 40000 kJ/hr

Infiltrated air : $1200 \text{ m}^3/\text{hr}$

Apparatus dew point

temperature : 10°C

Recirculated air : 60% of total

If the recirculated air is mixed with the conditioned air after the cooling coil, then find the following :

(i) The condition of air leaving the conditioner coil and before mixing with the recirculated air

(ii) The condition of air before entering the coil

(iii) The mass of air entering the cooler

(iv) The mass of total air passing through the hall

(v) Bypass factor of the cooling coil

(vi) The refrigerant load on the cooling coil in TR

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5. (a) Draw a neat diagram of lithium bromide water absorption system and explain its working. List the major field of applications of this system.

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- (b) Find the expression for the ideal COP for vapour absorption refrigeration system in terms of T_g , T_c and T_e , where
- T_g = Temperature at which heat is supplied to the generator
 - T_c = Temperature at which condensation takes place in condenser
 - T_e = Temperature at which refrigeration takes place in evaporator
- 7
6. (a) Prove that the enthalpy of the humid air remains constant along the wet-bulb temperature line of a psychrometric chart. 7
- (b) The humidity ratio of atmospheric air at 28 °C dry-bulb temperature and 760 mm Hg is 0.016 kg/kg of dry air. Using steam tables, determine—
- partial pressure of water vapour;
 - dew point temperature;
 - relative humidity;
 - specific enthalpy;
 - vapour density.
- 7

7. (a) Show that work done (w) in a polytropic compression is a function of initial temperature (T_1), pressure ratio $\left(\frac{P_2}{P_1}\right)$ and polytropic index (n), i.e.,
- $$w = f\left(T_1, \frac{P_2}{P_1}, n\right) \quad 7$$
- (b) Draw the temperature entropy and enthalpy-entropy diagram of a steam jet refrigeration system and write the expressions for the following efficiencies : 7
- Nozzle efficiency
 - Entrainment efficiency
 - Compression efficiency
8. (a) Discuss briefly the factors which govern the optimum effective temperature for comfort. Sketch 'comfort chart' and show on it the 'comfort zone'. 7
- (b) Draw a neat diagram of air-conditioning system required for hot and humid climate. Explain the working of different components and show the various processes schematically on psychrometric chart. 7

9. Write short notes on any *four* of the following : 14

- (a) Wet and dry compression in vapour compression cycle
- (b) Automatic expansion valve
- (c) Evaporative cooling
- (d) Secondary refrigerant
- (e) Wet-bulb temperature and thermodynamic wet-bulb temperature
