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B.E MECHANICAL ENGINEERING FOURTH YEAR FIRST SEMESTER EXAMINATION, 2024

REFRIGERATION AND AIR CONDITIONING

Time: Three hours **Full Marks-100**

Answer any five questions. Assume any unfurnished data suitably.

Use of Refrigerant Tables, Steam Table and Psychrometric Chart are permitted. For Problems on air-conditioning using Psychrometric charts, the students will have to attach the charts with their answer scripts.

Q: 1(a) A domestic food freezer maintains a temperature of -15^{0}C. The ambient temperature is 30^{0}C. The heat leaks into freezer at 1.75 KJ/s. What is the minimum power necessary to pump this heat out? **[5]**

(b) An inventor claims to have invented a refrigeration machine operating between -23^{0}C and 27^{0}C. It consumes 1KW electrical power and gives 21600 KJ of refrigeration effect in one hour. Comment on his claim. **[5]**

(c) Define the coefficient of performance of a refrigerator in words? Can it be greater than unity? Define refrigerating effect. Explain how one Ton of refrigeration is calculated? **[5+5]**

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Q: 2(a) Describe the following on Vapour compression refrigeration cycle. **[5+5]**

(i) Effect of suction vapour superheat, (ii) Effect of evaporator pressure.

(b) An ideal vapour compression system uses R-12 as the refrigerant. The system uses an evaporation temperature of 0^0C and a condenser temperature of 40^0C.The capacity of the system is 7 TR. Considering simple saturated vapor compression cycle, determine

i) The mass flow rate of refrigerant

ii) Power required to run the compressor

iii) Heat rejected in the condenser

iv) COP of the system.

Use the properties of R-12 from the table given below:

Temp.(0^0C)	Pressure (bar)	h_f(KJ/kg)	h_g (KJ/kg)	S_f(KJ/kg-k)	S_g(KJ/kg-k)
0	3.087	36.05	187.53	0.142	0.696
40	9.609	74.59	203.2	0.727	0.686

Take C_p for superheated vapour as 0.6 KJ/kg.K. **[10]**

Q: 3(a) In an aircraft cooling system, air enters the compressor at 0.1 MPa, 4^0C, and is compressed to 0.3 MPa with an isentropic efficiency of 72%. After being cooled to 55^0C at constant pressure in a heat exchanger the air then expands in a turbine to 0.1 MPa with an isentropic efficiency of 78%. The low temperature air absorbs a cooling load of 3 tonnes of refrigeration at constant pressure before re-entering the compressor which is driven by the turbine. Assuming air to be an ideal gas, determine the COP of the refrigerator, the driving power required and the air mass flow rate. **[10]**

(b) Sketch the Bell Coleman cycle on a P-v and T-s diagram and derive an expression for its COP. **[10]**

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Q: 4(a) Derive an expression of maximum COP for vapor absorption refrigeration cycle. **[10]**

(b) In an aqua-ammonia absorption refrigerator system, heat is supplied to the generator by condensing of steam entering at 0.2 MPa, 90% quality and leaving heat heat exchanger at saturated liquid at the same pressure. The temperature to be maintained in the refrigerator is -10^0C, and the ambient temperature is 30^0C.Estimate the maximum COP of the refrigerator. If the actual COP is 40% of the maximum COP and the refrigeration load is 20 tonnes, what will the required steam flow rate be? **[10]**

Q: 5(a) Define i) Relative humidity, ii) Specific humidity, iii) Dew point temperature. Derive the relation between the relative humidity (φ) and degree of saturation (μ). **[5+5]**

(b) Moist air at atmospheric pressure of 1.01325 bars and dry bulb temperature of 35^0 C exists at percentage humidity 0.5. For this moist air calculate, i) Relative humidity, ii) dew point temperature, iii) specific humidity. Solve this problem without use of Psychrometric chart. **[10]**

Q: 6(a) Sketch a psychrometric chart and indicate the lines of constant wet bulb temperature, constant specific volume and constant relative humidity. For moist air at 35^0C DBT and 28^0C WBT, find specific humidity, dew point temperature and relative humidity by plotting the plotting the point on the Psychrometric chart. **[5+5]**

(b) Atmospheric air at 760 mm Hg pressure and dry bulb and wet bulb temperature 15^0C and 11^0C respectively enters the heating coil whose temperature is 41^0C.The by-pass factor of the heating coil is 0.5.Determine the dry bulb temperature, the wet bulb temperature, relative humidity of the air leaving the heating coils, and also sensible heat added to air per kg of dry air. Solve the problem with help of Psychrometric chart. **[10]**

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Q: 7(a) Describe the followings: **[10]**

i) Cooling and Dehumidification, ii) By-pass factor of heating and cooling coils, iii) heating and dehumidification, iv) heating and humidification.

(b) 25 kg/s of air at 25^0C and 61% RH is mixed with 5kg/s of air at 5^0C DBT and 30% RH. Calculate the condition of mixed air. **[10]**

Q:8.(a) Describe the principle of operation, construction and working of centrifugal compressor. **[10]**

(b) In a centrifugal compressor, the air enters at 27^0C and leaves at 105^0C. The air is compressed through a pressure ratio of 2. Calculate the isentropic efficiency and power required by the compressor, if 30 kg of air is compressed per minute, Take Cp =1.005 kJ/kg.K and Cv=0.716 kJ/kg-K. **[10]**