MACHAKOS UNIVERSITY

University Examinations 2019/2020

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

FOURTH YEAR ……SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 408: REFRIGERATION AND AIR CONDITIONING

DATE: **TIME:**

INSTRUCTIONS:

This Paper consists of FIVE QUESTIONS. Answer ANY THREE QUESTIONS.

Steam Tables and Charts are provided

QUESTION ONE (30 MARKS)

a) Explain the use of a flash chamber in a vapour compression cycle. (2 marks)

b) In a vapour compression plant using refrigerant–12 has a suction pressure of 2.610bar and a condenser pressure of 13.66bar. The vapour is dry saturated at entry to the compressor and there is no under cooling of the condensate. The compression is carried out isentropically in two stages and a flash chamber is employed at an inter-stage pressure of 5.673bar. calculate the following:

(i) The amount of vapour bled off at the flash chamber

(ii) The state of the vapour at the inlet to the second stage of the compression

(iii) The refrigerating effect per kg of refrigerant in the evaporator

(iv) The work done per kg of refrigerant in the compressor

(v) The coefficient of performance.

Show the pressure – enthalpy diagram for the processes. (13 marks)

(c) Saturated air at 3^{o}C is required to be supplied to a room where temperature must be held at 22^{o}C with relative humidity at 55%. The air is heated and then water at 10^{o}C is sprayed t give the required humidity. Determine:

(i) Mass of spray water required per m3 of air at room conditions

(ii) Temperature to which the air must be heated

Neglect the fan power and assume the total pressure is constant at 1.01325bar

(7 marks)

QUESTION TWO (20 MARKS)

An Ammonia vapour-compression refrigerator operates between an evaporator pressure of 2.265bar and a condenser pressure of 13.11bar. The following cycles are to be compared; in each case there is assume isentropic compression:

a) The vapour is dry saturated at entry to the condenser

b) The vapour has a dryness fraction of 0.85 at entry to the compressor

c) The vapour is dry saturated at entry to the compressor

d) The vapour has 5K of super heat at entry to the compressor and the liquid after condensation is under-cooled by 10K.

In each case calculate the C.O.P.$_r$ and the refrigerating effect per kg of refrigerant. Also sketch the T-S diagram for each case.

What would be the C.O.P.$_r$ for a Carnot cycle operating between the same saturation temperatures.

(20 marks)

QUESTION THREE (20 MARKS)

(a) Discuss EIGHT classification of air conditioning systems (8 marks)

(b) It is required to design an air conditioning system for an industrial process for the following hot and wet conditions:

Outdoor conditions 30^{o}C DBT and 70% RH

Required inlet conditions – 20^{o}C DBT and 55% RH

Amount of free air circulated – 250m^3/min

Coil dew point temperature – 12^{o}C

The required condition is achieved by first cooling and dehumidifying and then by heating.

Calculate the following:

(i) The cooling capacity of the cooling coil and its by-pass factor

(ii) The heating capacity of the heating coil in kW and the surface temperature of the heating coil if the by-pass factor is 0.4

(iii) The mass of water vapour removed per hour.

(iv) Take the atmospheric pressure as 1.01325bar (12 marks)

QUESTION FOUR (20 MARKS)

An ammonia refrigerator operates between evaporating and condensing temperatures of -18^{o}C and 46^{o}C respectively. The vapour is dry saturated at the compressor inlet, the compression process is isentropic and there is no under-cooling of the condensate. Calculate the refrigerating effect per kg, the mass flow and power input per kW of refrigeration and the C.O.P.$_{r}$.

A flash chamber is introduced in the above refrigerator at an inter-stage pressure of 5.736 bar. Calculate the mass flow-rate of refrigerant through the condenser per kW of refrigeration, the power output per kW of refrigeration and the C.O.P.$_{r}$. (20 marks)

QUESTION FIVE (20 MARKS)

(a) The readings taken in a room from a sling psychrometer gave a dry and wet bulb temperature of 25^{o}C and 19.7^{o}C respectively. Using calculation determine:

(i) The specific humidity

(ii) The percentage saturation

(iii) The dew point

(iv) The specific volume of the mixture

(v) The enthalpy per kg of dry air

Take the atmospheric pressure as 1.01325bar

(b) If the atmosphere in (a) above is cooled to 5^{o}C and then heated until the dry bulb temperature is 17.5^{o}C, both processes being at constant pressure, determine from psychrometric chart, assuming that the air leaving the cooler is saturated:

(i) The final percentage saturation

(ii) The final specific humidity

(iii) The final wet bulb temperature

(iv) The amount of condensate collected at the cooler per kg of dry air

(v) The heat removed in the cooling process and that supplied in the heating process per kg of dry air. (20 marks)