



MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

FOURTH YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 408: REFRIGERATION AND AIR CONDITIONING

DATE: 18/3/2022

TIME: 8.30-10.30 AM

INSTRUCTIONS

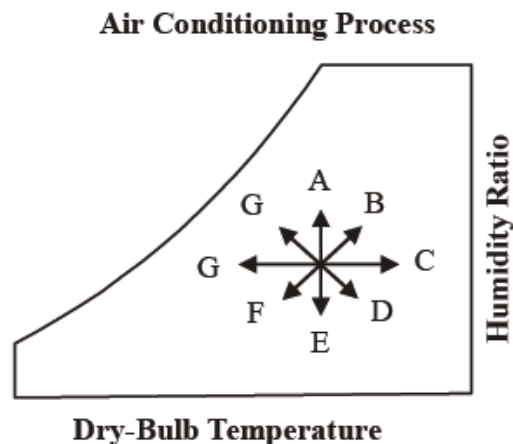
Answer question ONE and any other two questions..

Steam Tables and Charts are provided

QUESTION ONE (30 MARKS)

- a) What is the difference between a refrigerator and a heat pump? (2 marks)
- b) With the help of suitable sketches show that $COP_{\text{Heat Pump}} = COP_{\text{Refrigerator}} + 1$ (3 marks)
- c) Outline SIX desirable characteristics of ideal refrigerant and explain how refrigerants are designated. (5 marks)
- d) A refrigeration system using refrigerant R-12 operates between the pressure limits of 8.477bar and 1.237bar. The refrigerant leaves the condenser as saturated liquid and is throttled to a flash chamber operating at 3.626bar. The flashed refrigerant mixes with the refrigerant leaving the low-pressure compressor. The mixture is then compressed to condenser pressure by the high-pressure compressor. The liquid in the flash chamber is then throttled to evaporator pressure. Assuming the refrigerant leaves the evaporator as dry saturated vapor and both compression processes are isentropic, determine:
 - i. The fraction of refrigerant flashed in the flash chamber (2 marks)
 - ii. The amount of heat removed from the refrigerant (2 marks)
 - iii. Work input per unit mass of refrigerant in the condenser (2 marks)
 - iv. The coefficient of performance of the refrigerator (2 marks)

- b) Define following terms as used in air conditioning:
- Saturated air
 - Specific humidity
 - Relative humidity
 - Absolute humidity
 - Dew point temperature
 - By- Pass factor
- (3 marks)
- c) Name the processes represented by B, C, E, G from the figure below. (2 marks)



- d) Air at a rate of 120m^3 and dry bulb temperature 35°C and 50% relative humidity is cooled to 20°C dry bulb temperature by passing through a cooling coil. Determine the following:
- The relative humidity of air at exit (2 marks)
 - Capacity of the cooling coil (3 marks)
 - The amount of water vapour removed per hour (2 marks)

QUESTION TWO (20 MARKS)

- a) Discuss the main parts of equipment in an air conditioning cycle (4 marks)
- b) 5 grams of water vapour per kg of atmospheric air is removed and temperature of air after removing the water vapour becomes 25°C DBT. Find the followings:
- Relative humidity
 - Dew- point temperature if the atmospheric air is 35°C and 60% RH and pressure is 1.01325 bar. (6 marks)
- c) Air at 10°C and 70% RH and 30°C and 80% RH are mixed in equal proportions by weight in an adiabatic chamber and is left for sufficient time to reach equilibrium. Find the specific humidity and enthalpy of mixed air (5 marks)

- d) 40 m³ of air at 35°C DBT and 50% R.H. is cooled to 25°C DBT maintaining its specific humidity constant. Determine:
- Relative humidity (R.H.) of cooled air
 - Heat removed from air. (5 marks)

QUESTION THREE (20 MARKS)

An Ammonia vapour-compression refrigerator operates between an evaporator pressure of 2.680bar and a condenser pressure of 14.70bar. The following cycles are to be compared; in each case there is assume isentropic compression:

- The vapour is dry saturated at entry to the condenser (4 marks)
- The vapour has a dryness fraction of 0.9 at entry to the compressor (4 marks)
- The vapour is dry saturated at entry to the compressor (4 marks)
- The vapour has 5K of super heat at entry to the compressor and the liquid after condensation is under-cooled by 10K. (6 marks)

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. (2 marks)

QUESTION FOUR (20 MARKS)

- Draw the line diagram and explain the working of practical vapour absorption system. (5 marks)
- Outline SIX major differences between vapour compression refrigeration cycle and vapour absorption refrigeration cycle (6 marks)
- 0.004kg kg of water vapour per kg of atmospheric air is removed and the temperature of the air after removing the water vapour becomes 20°C. Determine:
 - Relative humidity after removing the water vapour
 - Dew point temperature of the leaving air
 - Water vapor removed per minute if the flow rate through a cooling coil at the rate of 280 m³/ min (9 marks)

Assume barometric pressure of 1.01325bar

QUESTION FIVE (20 MARKS)

- a) An ammonia refrigerator operates between evaporating and condensing temperatures of -26°C and 42°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. (12 marks)
- b) A flash chamber is introduced in the above refrigerator at an inter-stage pressure of 4.625bar. 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. (5 marks)