(The University of choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR
(Main Examination)

SECOND YEAR SECOND SEMESTER EXAMINATIONS FOR:

BACHELOR OF SCIENCE IN FOOD SCIENCE AND TECHNOLOGY

COURSE CODE: APT 203

COURSE TITLE: STOICHIOMETRY AND ENGINEERING THERMODYNAMICS

DATE: 19TH APRIL 2022   **TIME: 12.00-2.00 PM**

Instructions: This paper consists of 5 questions
Answer question 1 and any other 3 questions

Use the charts and tables provided as appropriate

MMUST observes ZERO tolerance to examination cheating

This paper consists of THREE printed pages. Please Turn Over

SECTION A
Question One (25 marks)
(a) With the aid of a P-v or T-s diagram describe the following thermodynamic processes
      i.   Isothermal process
      ii.   Isochoric process
      iii.   Isobaric process
      iv.   Adiabatic process   **(4 marks)**

(b) State and give the significance of the following
      i.   Zeroth law of thermodynamics
      ii.   First law of thermodynamics
      iii.   Second law of thermodynamics   **(3 marks)**

(c) Define the following terms used in phase change of a working fluid
      i.   Saturated vapour
      ii.   Superheated vapour
      iii. Wet vapour
      iv. Dry saturated vapour   **(4 marks)**

(d) Outline the criteria that is used in performing a Degree of Freedom Analysis (DFA)   **(5 marks)**

(e) Show the following processes on a psychrometric chart
      i.   Sensible heating
      ii.   Sensible cooling
      iii.   Humidification
      iv.   Dehumidification   **(4 marks)**

(f) Define the following terms that are used in process flow analysis
      i.   Purge
      ii.   Makeup
      iii.   Recycle
      iv.   Limiting reactant
      v.   Excess reactant   **(5 marks)**

SECTION B
Question Two (15 marks)
(a) A steam power plant operates between a boiler pressure of 42 bar and condenser pressure of 0.035 bar. Calculate the limits of the cycle efficiency, the work ratio and the specific steam consumption
      i.   For a Carnot Cycle using wet steam
      ii.   For a Rankine cycle with dry saturated steam at the entry to the turbine   **(9 marks)**

(b) With the aid of a diagram outline the components and processes of a typical Rankine cycle **(6 marks)**

Question Three (15 marks)

(a) To make strawberry jam, strawberries containing 15 wt% solids and 85 wt% water are crushed. The crushed strawberries and sugar are mixed in a 4/5 mass ratio and the mixture is heated to evaporate water. The residue contains one-third water by mass. Calculate the amounts of strawberries needed to make 100 g of jam, and of evaporated water. **(9 marks)**

(b) Humid air at 28°C has a dew point of 8°C. Using the psychrometric chart provided, determine the following: relative humidity, absolute humidity, wet-bulb temperature, dry-bulb temperature, humid volume, specific enthalpy, and mass of air that contains 2 kg of water, and volume occupied by air that contains 2 kg of water. **(6 marks)**

Question Four (15 marks)

The process for producing pure ethanol starts with a fresh feed stream that contains 96% ethanol and 4% water. The stream is fed to a distillation tower along with a stream of benzene plus a small amount of ethanol (this stream is being recycled from another portion of the system). This distillation tower produces two outgoing streams: the overhead stream (all vapor) is a mixture of water, benzene, and ethanol, and the bottom stream (all liquid) is 100% ethanol. The overhead stream is condensed to an all-liquid stream. The liquid stream is sent to a decanter where it separates into two distinct liquid phases. The top layer in the decanter consists primarily of benzene with a small amount of ethanol and is sent back to the first distillation tower to be mixed with the incoming ethanol/water mixture being fed to the system. The bottom layer from the decanter contains ethanol, water, and benzene. This stream is fed to a second distillation tower. The overhead stream from this second distillation tower is also all vapors and consists of ethanol, water, and benzene. This vapor stream is mixed with the overhead vapor stream from the first distillation tower before both streams are condensed prior to the decanter. The bottoms stream from this second tower (again all liquid) consists of water and ethanol. This bottoms stream is fed to a third distillation tower. The overhead product from this third distillation tower is a 96 wt% ethanol/4.0 wt% water stream that is sent to the start of the entire process to be mixed with the incoming feed of ethanol and water. The bottoms stream from the third distillation tower is all water. Draw a flow diagram for the process described earlier clearly labeling all processing units and all streams.

(15 marks)

Question Five (15 marks)

(a) With the aid of a diagram outline the functions of the components of a typical vapour compression refrigeration system **(6 marks)**

(b) A refrigeration machine is required to produce i.e., at 0°C from water at 20°C. The machine has a condenser temperature of 298 K while the evaporator temperature is 268 K. The relative efficiency of the machine is 50% and 6 kg of Freon-12 refrigerant is circulated through the system per minute. The refrigerant enters the compressor with a dryness fraction of 0.6. Specific heat of water is 4.187 kJ/kg K and the latent heat of ice is 335 kJ/kg. Calculate the amount of ice produced on 24 hours. The table of properties of Freon-12 is given as

Temperature K	Liquid heat kJ/kg	Latent heat kJ/g	Entropy of liquid kJ/kg
298	59.7	138.0	0.2232
268	31.4	154.0	0.1251

(9 marks)