KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2017/2018 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER
MAIN EXAMINATIONS

FOR THE BACHELOR OF RENEWABLE ENERGY AND BIOFUELS TECHNOLOGY

COURSE CODE: IPT 327

COURSE TITLE: HEAT AND MASS TRANSFER

DURATION: **2 HOURS**

DATE: 15/10/ 2018 **TIME:** 9 – 11Am

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- Indicate **answered questions** on the front cover.
- Start every question on a new page and make sure question's number is written on each page.

This paper consists of **4** printed pages. Please Turn Over

QUESTION ONE (30 MARKS)

a) State Newton's law of cooling (2 marks)

b) Differentiate between natural convection and forced convection (3 marks)

c) Make a neat labeled sketch of a counter-flow recuperator together with the temperature profiles for two fluids A and B (7marks)

d) Briefly describe the process of natural convection in a liquid (4 marks)

e) A spherical shaped vessel of 1m outside diameter is 100mm thick. Find the rate of heat loss, if the temperature difference between the inner and outside surface is 150 k. Take λ for the vessel material as 0.2 W/mK (4 marks)

f) A small hemispherical oven is built of an inner layer of insulating firebrick 125mm thick and an outer covering of 85% magnesia 40mm thick. The inner surface of the oven is at 800°C and the heat transfer coefficient for the outside surface is $10W/m^2k$; the room temperature is 20°C. Calculate the rate of heat loss through the hemisphere if the inside radius is 0.6m. Take the thermal conductivities of firebrick and 85% magnesia as 0.31 and 0.05W/mk (10 marks)

QUESTION TWO (20 MARKS)

a) Define the following terms:
   i. Saturation state
   ii. Dry saturated vapour (4 marks)

b) Define the thermal conductivity of a material (2 marks)

c) State the names of four types of heat exchangers (2 marks)

d) Differentiate between parallel flow and counter-flow with respect to heat exchangers (2 marks)

e) Explain the reason why higher heat transfer rates are possible with drop wise condensation (3 ½ marks)

f) Sketch the boundary layer development of flow over a flat vertical plate and explain its significance during heat transfer (6 ½ marks)

QUESTION THREE (20 MARKS)

a) Describe the operation principle of a cross-flow recuperator (5 marks)

b) State four factors on which the heat transfer coefficient, α depends upon in forced convection (4 marks)

c) With the help of a boiling curve, explain the process of boiling in water (7 ½ marks)

d) Give the reason why higher heat transfer rates are possible with dropwise condensation (3 ½ marks)

QUESTION FOUR (20 MARKS)

a) Calculate the diffusion coefficient for a certain gas, XO_2 in air at a pressure of 1.5 atmospheres and 15°C, given that;

V_{XO2} =33.0 V_{AIR} =29.9 M_{XO2} =44.0 M_{AIR} =28.9 (4 marks)

b) i) Define convective mass transfer (1 ½ marks)
ii) Give an expression for determining the convective mass transfer coefficient (1 mark)

c) Outline the procedure for solid-solid extraction (3 ½ marks)

d) i) Saturated steam condenses on the outside of a 5cm-diameter tube, 50cm high. If the saturation temperature of the steam is 302K, and cooling water maintains the wall temperature at 299 K, determine the average heat transfer coefficient

From the table of water properties, we have:

$h_{fg} = 2.432 \times 10^6 J/kg$

$\rho_v = 0.03 kg/m^3$
$k_l = 0.611 W/Mk$
$\rho_l = 996 kg/m^3$
$v_l = 0.87 \times 10^{-6} m^2/s$

(5 marks)

ii) Determine the total condensation for the steam in (i) above (6 marks)

QUESTION FIVE (20 MARKS)

a) Define the following:
   i) Raoult's law
   ii) Dalton's law (3 marks)

b) State the main variables that affect the purity of products in continuous distillation (2 marks)

c) Outline the process of batch distillation (15 marks)