KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR

FOURTH YEAR FIRST SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF
B.SC RENEWABLE ENERGY AND BIOFUELS TECHNOLOGY

COURSE CODE: PRD 471

COURSE TITLE: THERMODYNAMICS IV

DURATION: 2 HOURS

DATE: 15/07/2021 **TIME:** 2:00-4:00PM

INSTRUCTIONS TO CANDIDATES

(i) Answer Question 1 **(Compulsory)** and any other **TWO** questions
(ii) All symbols have their usual meaning
(iii) Use steam tables provided

This paper consists of **3** printed pages. Please Turn Over

QUESTION ONE (Compulsory) – 30 MARKS

a) What is the implication of the Grashof number with regard to fluid flow?

(4 Marks)

b) Differentiate between the following bodies.

(i) Black body

(2 Marks)

(ii) Grey body

(2 Marks)

c) Use a sketch to show the progression in the velocity boundary layer as the fluid flows

(5 Marks)

(d) Explain briefly the differences between the following types of heat exchangers

(i) Recuperative

(2 Marks)

(ii) Regenerative

(2 Marks)

(e) Draw a well labeled diagram to show the temperature distribution in a parallel-flow heat exchanger

(5 Marks)

(f) Define the following.

i) Heat exchanger effectiveness

(2 Marks)

ii) Thermal capacity

(2 Marks)

(g) Define the Stefan-Boltzmann law

(4 Marks)

QUESTION TWO (20 Marks)

Calculate the heat transfer coefficient for water flowing through a 25mm diameter tube at a mass flow rate of 1.8 kg/s when the mean bulk temperature is 42^0C.

For turbulent flow of a liquid, take:

$$Nu = Re^{0.8} Pr^{0.4}$$

(20 Marks)

QUESTION THREE (20 Marks)

A single pass shell and tube counter-flow heat exchanger uses waste gas on the shell side to heat a liquid in the tubes. The waste gas enters at a temperature of 400°C with a mass flow rate of 40kg/s. The water enters at a temperature of 100°C with a mass flow rate of 3kg/s.

Assuming that the velocity is not to exceed 1m/s, use the data provided below to calculate:

i. The required number of tubes

(8 Marks)

ii. The effectiveness of the heat exchanger

(10 Marks)

iii. The exit temperature of the water

(2 Marks)

DATA

- Tube inside diameter = 10mm
- Tube outside diameter = 12.5mm
- Tube length = 4m
- Specific heat capacity of waste gas = 1.04kJ/kgK
- Specific heat capacity of liquid = 1.5kJ/kgK
- Density of liquid = 500kg/m^3
- Coefficient of heat transfer of the shell side = 0.26kW/m^2K
- Coefficient of heat transfer of the tube side = 0.58kW/m^2K

QUESTION FOUR (20 Marks)

In a chemical plant, a solution of density 1100 kg/m^3 and a specific heat of 4.6 kJ/kgK is to be heated from 65^{0}C to 100^{0}C; the flow of solution required is 11.8 kg/s. It is desired to use a tubular heat exchanger, the solution flowing at about 1.2 m/s in a 25mm bore iron tubes, and being heated by wet steam at 115^{0}C. The length of the tubes must not exceed 3.5 m. The inside and outside heat transfer coefficients are 5 and 10 kW/m^2K, respectively. The thermal resistance of the iron tube is negligible.

Estimate the:

a) number of tubes required

(8 Marks)

b) number of tube passes required

(12 Marks)