KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2020/2021 ACADEMIC YEAR

THIRD YEAR SECONDSEMESTER
SPECIAL/SUPPLIMENTARY EXAMINATIONS

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

COURSE CODE: REN 322

COURSE TITLE: HEAT AND MASS TRANSFER

DURATION: 2 HOURS

DATE: 20/1/2022 **TIME: 8-10AM**

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

a) Show that the heat transfer, Q through a cylinder/pipe can be expressed as:

$$Q = \frac{2\pi k(t_1 - t_2)}{ln\left(\frac{r_2}{r_1}\right)}$$

(8 Marks)

b) A steel pipe of 100mm bore and 7mm thickness, carrying steam at 260^0C is insulated with 40mm of moulded high-temperature diatomaceous earth covering. This covering is in turn insulated with 60mm of asbestos felt. The heat transfer coefficients for the inside and outside

surfaces are 550 and 15 kW/m^{2}K respectively, and the thermal conductivities of steel, diatomaceous earth, and asbestos felt are 50, 0.09, and 0.07 W/mK respectively.

i. Calculate the rate at which the heat is lost by steam per metre length of pipe if the atmospheric temperature is 15^{0}C.

(10 Marks)

ii. Calculate the temperature of the outside surface.

(2 Marks)

QUESTION THREE – 20 MARKS

Calculate the rate of heat loss in air by natural convection per metre length from a horizontal pipe of 150 mm diameter, the surface of which is at 277°C, and the room temperature is 17°C. For the horizontal pipe take;

$$Nu = 0.527Pr^{0.5}(Pr + 0.952)^{-0.25}Gr^{0.25}$$

Evaluate the properties at surface temperature, and take the coefficient of cubical expansion, β to be T^{-1}; where T is the absolute temperature in Kelvin.

(20 Marks)

QUESTION FOUR – 20 MARKS

A hot steel billet measuring 4m long, 1m wide, and 1m thick has 95% of its surface exposed. The billet is grey and has an emissivity of 0.3, its thermal conductivity is very high, and the surroundings are at 28°C. The steel has a specific heat capacity of 0.45kJ/kgK, and a density of 7810kg/m^3. Neglecting the heat losses through conduction and convection, calculate the time that the billet will take to cool from 1300°C to 850°C.

(20 Marks)