UNIVERSITY OF GHANA

FACULTY OF ENGINEERING SCIENCES

BSc. (ENG) SECOND SEMESTER EXAMINATIONS: 2012/2013

MSEN 308 HEAT & MASS TRANSFER (3 CREDITS)

TIME ALLOWED: 3 HOURS

Answer ALL Questions :

Question 1

a. Give the physical mechanisms associated with heat transfer by conduction, convection and radiation. **[3 Marks]**

b. The inner surface of a combustion chamber wall receives heat from the products of combustion. The wall is being cooled by a coolant on the outer side. Compute the overall heat-transfer coefficient and draw the equivalent thermal circuit. **[5 Marks]**

c. You are appointed as a Materials Engineer in a Nanomaterials company in Accra. You are tasked to select a conductive material from a list of materials for shipping abroad to other electronics company. Which material(s) will you advise for shipment given their Thermal conductivity values? Give reasons for your choice of material(s). **[3 Marks]**

Table 1. List of materials with their thermal conductivity values.

Material	**Thermal Conductivity (W/mK)**
PPV polymer	204.2
Glass	0.67
Chrome Steel	12.8
Carbon Steel	43.3
Asbestos	0.11
Copper	386.0

d. State Fourier's law. The heat flux through a layer of material 40 mm thick conducting heat under steady state with a temperature drop of 40 °C was measured as 106 W/m^2. Determine the thermal conductivity of the material. **[4 Marks]**

e. Calculate the heat flow across a flat wall of 5 cm thickness with a constant thermal conductivity of 100 W/m K when the surface temperatures are steady at 90 °C and 20 °C. The wall area is 3 m^2. Also find the temperature gradient in the flow direction. Comment on the material with regards to its thermal conductivity. **[5 Marks]**

Question 2

a. Define Nusselt, Reynolds, Prandtl and Stanton numbers. Explain their significance in forced convection. **[4 Marks]**

b. Water at 50 °C flows through a tube of 1.5 cm diameter and 3 m long with a velocity of 1m/s. The tube wall is maintained at a constant temperature of 90 °C. Calculate the heat transfer coefficient and the total amount of heat transferred if the exit water temperature is 64 °C. The properties of water are: density (ρ) = 990 kg/m^3, kinematic viscosity (υ) = 0.517 x 10^{-6} m^2/s, thermal conductivity (k) = 0.65 W/mK, Prandtl number (Pr) = 3.15, Specific Heat Capacity (C_p) = 4184 J/kgK. **[6 Marks]**

c. What are the conditions for determining heat transfer coefficient to fluid in a tube in forced convection? **[5 Marks]**

d. What is the Dittus-Boelter equation? Where and when does it apply? **[5 Marks]**

e. Define Biot number and Fourier number. Give the significance of the Biot number and under what conditions can internal temperature gradient be neglected? **[5 Marks]**

Question 3

a. What are heat exchangers? List the types of heat exchangers. **[5 Marks]**

b. In a ceramic processing plant, water is to be cooled from 18 °C to 6.5 °C by using brine solution entering at an inlet temperature of -1.1 °C and leaving at 2.9 °C. What area is required when using a shell-and-tube heat exchanger with water making one shell pass and the brine making two tube passes? Assume an overall average heat transfer coefficient of 850 W/m^2K and the design heat load of 6000 W. **[6 Marks]**

c. Derive an expression for the mean temperature difference in a parallel flow heat exchanger. **[5 Marks]**

d. Give the dimensionless numbers relating to both Forced convection and Natural convection. Sketch the temperature profile for heat flowing through a tube at a constant wall temperature (T_w) and at a constant heat flux (q/A) showing the thermal region and fully developed temperature profiles. **[5 Marks]**

e. (i) A flat plate of length 1 m and width 0.5 m is placed in air stream at 30 °C blowing parallel to it. The convective heat transfer coefficient is 30 W/m^2K. Calculate the heat transfer if the plate is maintained at a temperature of 300 °C. **[2 Marks]**

(ii) A 'radiator' in a domestic heating system operates at a surface temperature of 55 °C. Determine the rate at which it emits radiant heat per unit area if it behaves as a black body. **[2 Marks]**