UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester 7 Examination in Engineering: June 2014

Module Number: ME 7321 **Module Name: Heat Transfer**

[Two Hours]

[Answer all questions. Your drawings should be neat, clear and precise. Make reasonable assumptions wherever necessary and state them clearly]

Q1. Figure Q1 shows a composite wall made up of five rectangular sections labelled 1, 2, 3, 4, and 5. Their thermal conductivities are; $k_1 = k_3 = 80$ W/mK, $k_2 = 120$ W/mK, $k_4 = 100$ W/mK, $k_5 = 150$ W/mK. Assuming 1-D steady state heat conduction in horizontal direction as indicated by the arrow ;

a) Construct the thermal circuit and find the total thermal resistance.

b) If the left and right walls are exposed to air at temperatures of 20 °C and 80 °C respectively, calculate the rate of heat flow through the wall. Take the convective heat trnsfer coefficient as 15 W/m^{2}K on both sides.

[08 marks]

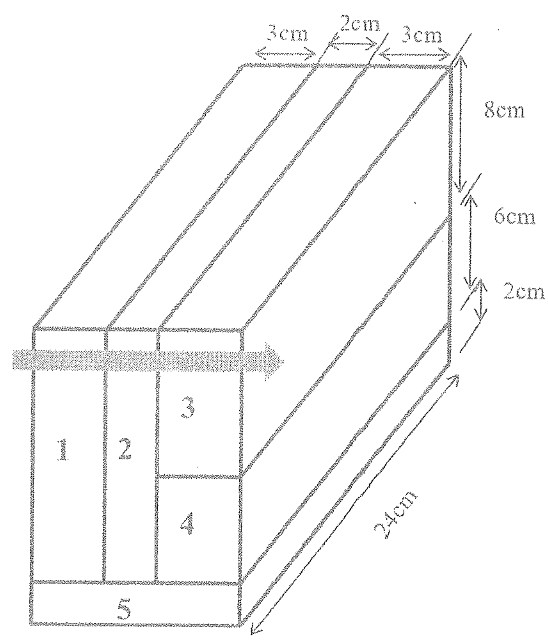

Figure Q1

Q2. Plan view of a cylindrical fuel element used in nuclear power reactors is shown in Figure Q2. Thorium fuel is in the centre, surrounded by graphite cladding and the coolant. Thorium generates heat at a rate of 10^8 W/m^3. Thermal conductivities of thorium and graphite are 57 W/mK and 3 W/mK respectively. Coolant temperature is maintained at 600 K and the convective heat trnsfer coefficient on the outer surface of graphite is 2000 W/m^{2}K.

a) Assess the outer surface temperature of the graphite cladding

b) If the melting temperature of graphite is 3200 °C, will the cladding prevail?

[06 marks]

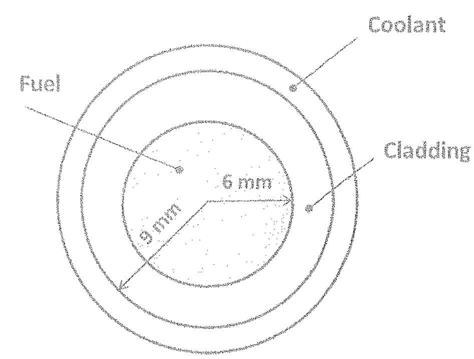

Figure Q2

Q3. a) What are the necessary conditions to apply *Lumped capacitance method* to analyse a transient heat conduction problem?

b) A thermocouple junction that may be approximated by a sphere is to be used to measure temperature in a gas stream. The convection heat transfer coefficient (h) between the junction and the gas can be taken as 400 W/m^{2}K. Following properties are also given for the junction: thermal conductivity (k) = 20 W/mK, Cp = 400 J/kgK, and ρ = 8500 kg/m^3.

i) Determine the junction diameter needed for the thermocouple to have a time constant of 1s.

ii) If the junction is at 25°C and is placed in a gas stream that is at 200°C, how long will it take for the junction to reach 199°C?

With standard notations you may use the following equations:

$$Bi = \frac{h\,L_c}{k} \qquad \tau_t = \left(\frac{1}{hA_s}\right)(\rho V C_p) \qquad \frac{T(t)-T_\infty}{T_i-T_\infty} = \exp\left[-\left(\frac{hA_s}{\rho V C_p}\right)t\right]$$

[06 marks]