UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

SECOND SEMESTER EXAMINATIONS, MAY 2018

COURSE NO: MR 358
COURSE NAME: **HEAT TRANSFER**
CLASS: BSc **MR III/MC III** TIME: 3 HRS

Name: _____ Index Number: _____

ATTEMPT ANY THREE QUESTIONS

Q1. a) Explain, define or state each of the following heat transfer terms/laws:

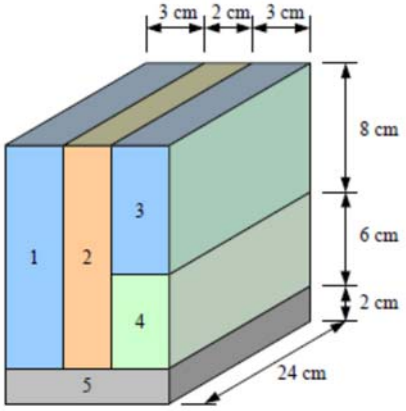
i) Conduction ii) Convection iii) Radiation
iv) Blackbody v) Gray body

[10 marks]

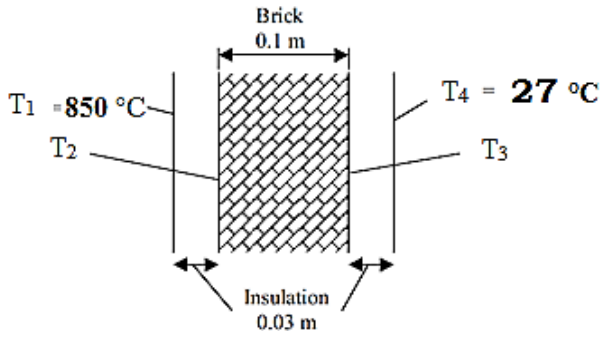
b) A composite panel consists of five sections, as shown in the figure. $k_1 = k_3 = 160$ W/m.K; $k_2 = 220$ W/m.K; $k_4 = 200$ W/m.K, and $k_5 = 270$ W/m.K.

i) Construct the thermal circuit model and find the total thermal resistance. **[15 marks]**

ii) If $T_{left} = 25$ ºC, $T_{right} = 180$ ºC and h = 25 W/m^2.K on both sides, find the heat transfer rate through the composite. **[8 marks]**



Q2. Consider the heat transfer situation illustrated below:



a) Represent this system by a suitable circuit diagram of resistances **[5 marks]**

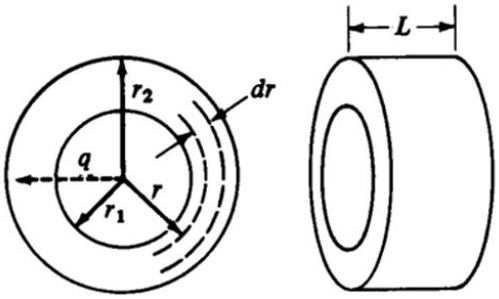
b) Determine the individual and overall thermal resistances across the system per unit area **[16 marks]**

c) Calculate the overall heat flux q across the insulating wall in W/m^2 **[4 marks]**

d) Estimate the temperatures T_2 and T_3 in °C. **[8 marks]**

Assume $k_{brick} = k_2 = 0.72$ W/m-K; $k_{insulation} = k_1 = k_3 = 0.067$ W/m-K

Q3. a) Use Fourier's law to derive an expression for the heat flow *q*, through the concentric cylinder illustrated below: **[6 marks]**



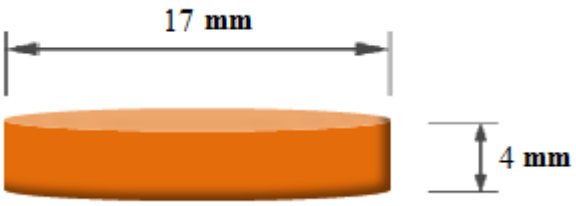
b) A cylindrical tube 120 mm OD is insulated with a 60-mm layer of silica foam, for which the conductivity is 0.0625 W/m-°C, followed with a 36-mm layer of cork with a conductivity of 0.0525 W/m-°C. If the temperature of the outer surface of the pipe is 250 °C and the temperature of the outer surface of the cork is 30 °C, calculate:

i) The logarithmic mean radius for the silica layer **[5 marks]**
ii) The logarithmic mean radius for the cork layer **[5 marks]**
iii) The heat loss in watts per meter of pipe. **[5 marks]**

c) A sudden cold wave drops the atmospheric temperature of an environment from 6 °C to -32 °C for 18h. The thermal diffusivity of soil is 0.0011 m^2/h

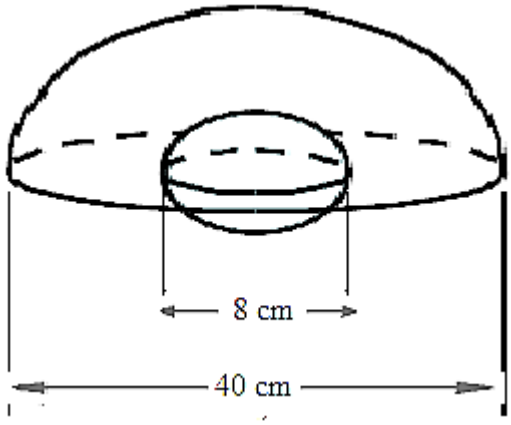
i) How deep would a water pipeline have to be buried to be in no danger of freezing? **[6 marks]**
ii) What is the penetration distance under these conditions? **[6 marks]**

Q4 a) A hot cylindrical pellet of hausmannite (Mn_3O_4) of 17 mm diameter and 4-mm thickness having a surface temperature of 1150 °C is suddenly exposed to an environment of temperature 27 °C.



The convective heat transfer coefficient can be approximated as 45 W/m².K on the top and the side surfaces, and 25 W/m².K on the bottom surface and the emissivity of the cylindrical MnO-pellet is 0.68 on all sides. Neglecting the effects of heat loss due to conduction, calculate the rate of heat loss from the pellet to the air. **[16 marks]**

b) A 40 cm diameter dome at 450 °C, with absorptivity and emissivity of 1 is placed over an 8 cm diameter glass sphere at 250 °C and suspended in the air so that the dome and sphere are concentric. The properties of the glass sphere are: k = 1.4 W/m.K, ρ = 2225 kg/m³, c_p = 835 J/kg.K, ε = 0.9, α = 0.8



Find:

i) The rate of heat loss due to convection from the sphere if convection coefficient is 15 W/m²K and the air temperature is 20 °C. **[2 ½ marks]**

ii) The rate of heat loss from the sphere due to radiation. **[2 ½ marks]**

iii) The shape factor from the sphere to the dome. **[2 ½ marks]**

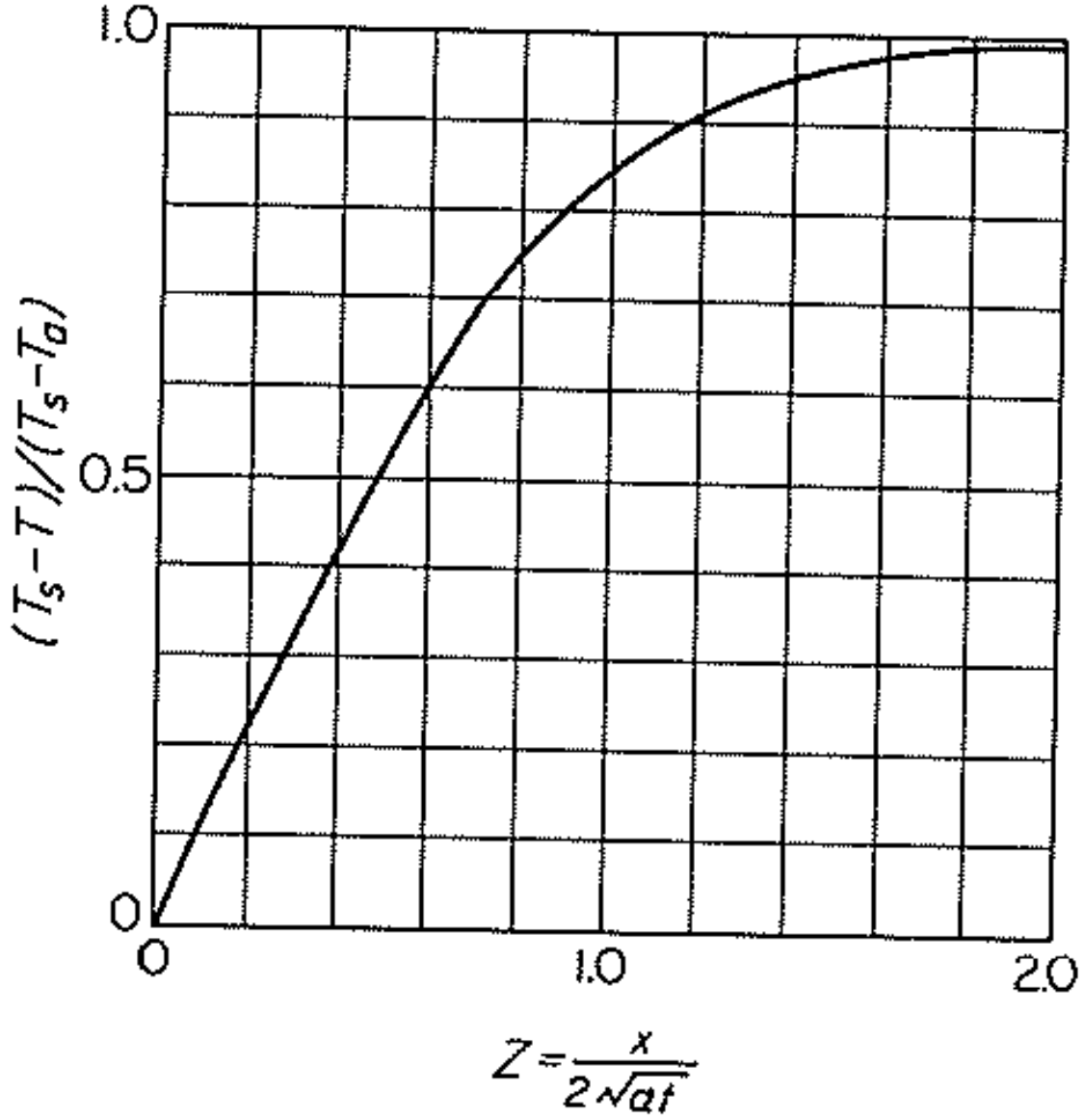
iv) The shape factor from the dome to the sphere. **[2 ½ marks]**

v) The rate of heat loss from the inside surface of the dome. **[2 ½ marks]**

vi) The rate of heat transfer from the inside surface of the dome to the sphere. **[2 ½ marks]**

vii) The net heat transfer of the sphere. Is the sphere losing heat or gaining heat? **[2 marks]**

Course Examiners:J. R. Dankwah/



$$\frac{T_s - T}{T_s - T_a} = \frac{2}{\sqrt{\pi}} \int_0^Z e^{-Z^2} dZ$$

$$Z = \frac{x}{2\sqrt{\alpha t}}$$