NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCE
BACHELOR OF SCIENCE – APPLIED CHEMISTRY
Part Two - December 2002 Examination

SCH 2108 Transport Phenomena

Duration of Examination 3 Hours

Instructions to Candidates:
1. Answer question 1 and any other three questions.
2. Each question carries equal marks.
3. Show all your steps clearly in your calculation.
4. Start the answers for each question on a new page.

1. (i) What do you understand by the terms *fundamental* and *derived quantities* in dimensional analysis?

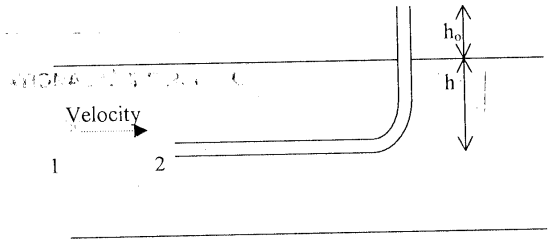
(ii) State the continuity equation and explain the principle behind it.

(iii) The standard atmosphere is defined as 760 mm Hg. What is the pressure in the following units (to 3 significant figures):
- Pascals
- lbf/in^2
- metres of water
- ft of water

Only the following information should be used:

Density of mercury		13.59 g/cm^3	Density of water		1000 kg/m^3
1 lbf	=	4.4482 N	1 in	=	25.4 mm
1 ft	=	0.3048 m			

(iv) A simple pitot tube, sometimes called an impact tube, may be used to measure the velocity of a fluid flowing as shown on the next page. Derive an expression for the velocity in terms of the given quantities.



2. (i) What do you understand by the term *viscosity* of a fluid? With the help of a neat diagram describe a Newtonian and Non-Newtonian fluid. Give an example of each.

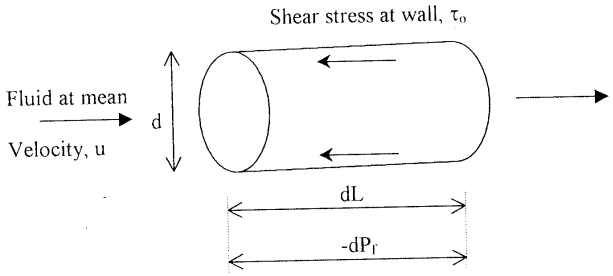
   (ii) In the detailed Bernoulli equation what does each term represent?

   (iii) What are the physical meanings of the the following dimensionless groups:
   - Reynolds number
   - Prandtl number
   - Nusselt number

3. (i) Mention any three types of flow measuring devices and explain their operating modes.

   (ii) What is the difference between compressible and incompressible fluids?

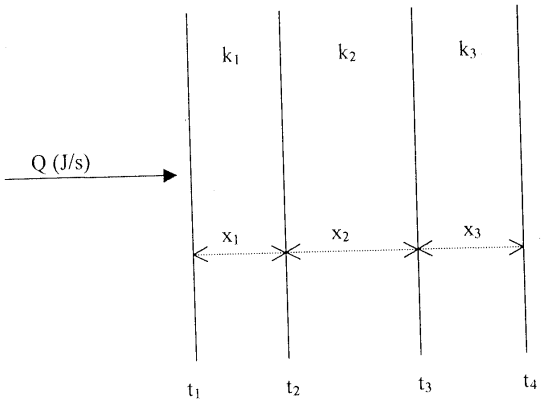
   (iii) By applying a force balance on the element shown below, show that the pressure drop ΔP, across this element is given by $-\Delta P_f = 4\left(\frac{\tau_o}{\rho u^2}\right)\left(\frac{L}{d}\right)\rho u^2$. What is the name of the dimensionless group, $\left(\frac{\tau_o}{\rho u^2}\right)$ and what does it imply?



4. (i) Discuss the three mechanisms of heat transfer.

(ii) For the diagram below show that the rate of heat transfer by conduction Q, through three slabs in series is given by

$$Q = \frac{(t_1 - t_4)}{\sum_{i=1}^{n=3} \frac{x_i}{k_i A}}$$



If k_1 and k_3 are the same and k_2 is twice as much as k_1 derive the new expression for Q in terms of k_3.

(iii) What do you understand by the term equimolar counter diffusion?

(iv) When mass transfer of components A and B occur through a stationary gas after which A is absorbed with B being insoluble, the total molar flux of A becomes $N_A = -\left(\frac{C_T}{C_B}\right) D \frac{dC_A}{dy}$, where C_T is the total concentration of A and B, D diffusion coefficient. Why does this expression differ from Fick's Law and by how much?

5. (i) A horizontal steel pipe, 60 mm o.d., carries steam at 160°C. It is lagged with 12 mm rock wool which has an outer surface temperature of 60°C. If the surrounding air temperature is 20 °C what will be the heat lost by convection per meter of pipe.

Data

Geometry	Laminar Flow	Turbulent Flow
	Gr.Pr. = $10^4 - 10^9$	Gr.Pr. = $10^9 - 10^{12}$
Horizontal Cylinder with outer diameter, d.	$h = 0.27\left(\frac{\Delta T}{d}\right)^{0.25}$ *IMP* $h = 1.31\left(\frac{\Delta T}{d}\right)^{0.25}$ *S.I*	$h = 0.18\Delta T^{0.333}$ *IMP* $h = 1.26\Delta T^{0.333}$ *S.I*

6. (i) How does fouling affect the economics of heat exchanger operations? State four of these effects.

(ii) When is it necessary to use the log mean temperature driving force (LMTD) in the calculation of temperature driving force? Is the LMTD applicable to both counter and parallel flow arrangements?

(iii) A fire boiler has hot air flowing through 2 mm thick steel tubes with an inside diameter of 3.8 cm. The inside heat transfer coefficient is 55 W/m^{2}K. On the outside of the tubes water boils with a heat transfer coefficient of 7500 W/m^{2}K. The steel has a thermal conductivity of 50 W/mK and the fouling coefficients are:

Boiler feed water	0.0002 m^{2}K/W
Air	0.0004 m^{2}K/W

Calculate the overall heat transfer coefficient based on the inside area and comment on how enhancement might be achieved. What would be the effect of using river water in place of boiler feed water.

The End