NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
SUPPLEMENTARY EXAMINATIONS – JULY 2003
TRANSPORT PHENOMENA – SCH 2108
TIME – (3) THREE HOURS

INSTRUCTIONS TO CANDIDATES

Answer **ONLY FOUR** questions from this paper. Total marks is 100.

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1. (a) A dimensionless combination of variables that is important in the study of viscous flow through pipes is called the Reynolds number, Re, defined as $\rho\frac{VD}{\mu}$ where ρ is the fluid density, V the mean velocity, D is the pipe diameter and μ the fluid viscosity. A Newtonian fluid having a viscosity of $0.38 N.s/m^2$ and a specific gravity of 0.91 flows through a 25mm-diameter pipe with a velocity of 2.6m/s. Determine the value of the Reynolds number using :

   (i) S1 units
   (ii) BG units

   To convert S1 units to BG units;

   ρ multiply by 1.940×10^{-2}

   V multiply by 3.281

   D multiply by 3.281

   μ multiply by 2.089×10^{-2}

   $1N = 1kg.m/s^2$

   (b) Derive the continuity equation for an incompressible fluid.

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

2. (a) Define static fluid. With the aid of a sketch diagram and equations explain Newtonian and non-Newtonian fluids.

   (b) List ***any five (5)*** properties of fluids and explain them.

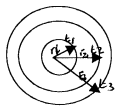
3. (a) The wall of an oven consists of three (3) layers of brick. The inside is built of 80mm of firebrick, k = 0.68W/m°C surrounded by 40mm of insulating brick, k = 0.5W/m°C and an outside layer of 60mm of building brick, k = 0.40W/m°C. The oven operates at 1600°C and it is anticipated that the outer side of the wall can be maintained at 125°C by the circulation of air. How much heat will be lost per square meter of surface and what are the temperatures at the interfaces of the layers?

(b) Define the following terms:

(i) Conduction
(ii) Convection
(iii) Radiation

(c) What does LMTD mean?

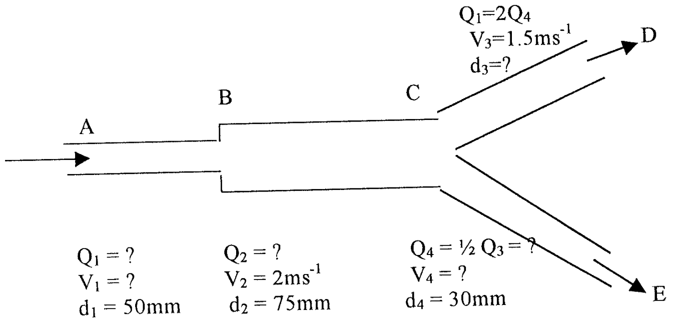
4. (a) For the diagram below show that $t_1 - t_2 = \frac{2.3q}{2\Pi k_a}\log\frac{D_2}{D_1} + \frac{2.3q}{2\Pi k_b}\log\frac{D_3}{D_2}$



(b) A glass pipe has an outside diameter of 60cm and an inside diameter of 50cm. It will be used to transport a fluid which maintains the inner surface at 200°C. It is expected that the outside of the pipe wall be maintained at 175°C. What heat flow will occur? k = 0.63W/m°C.

(c) Draw a sketch diagram for a countercurrent heat transfer flow labeling it clearly.

5. (a) Water flows through a pipe AB as shown below of diameter d_1 = 50mm which in series with a pipe BC of diameter d_2 = 75mm in which the mean velocity $v_2 = 2ms^{-1}$. At C the pipe forks and one branch CD is of diameter d_3 such that the mean velocity $v_3 = 1.5ms^{-1}$. The other branch CE is of diameter d_4 = 30mm and conditions are such that the discharge Q_2 from BC divides so that $Q_4 = \frac{1}{2}Q_3$. Calculate values of Q_1, V_1, Q_2, Q_3, d_3, Q_4 and V_4



(b) Explain the difference between laminar and turbulent regime.

6. (a) Estimate the diffusion coefficient for the H_2(A) – NH_3(B) system at 25°C and 1 atm pressure. Use the collision integrals to find the diffusivity at 85°C. Additional information:

$M_A = 2$; $M_B = 17$; $\sigma_A = 2.827 \times 10^{-10}$m; $\frac{\varepsilon_A}{k} = 59.7K$

$\sigma_B = 2.900 \times 10^{-10}$m; $\frac{\varepsilon_B}{k} = 558.3K$

$\sigma_{AB} = \frac{\sigma_A + \sigma_B}{2}$; $\frac{\varepsilon_{AB}}{k} = \left(\frac{\varepsilon_A}{k} X \frac{\varepsilon_B}{k}\right)^{0.5}$; $\frac{kT}{\varepsilon_{AB}}$; $\Omega_{D1} = 1.158$

$$D_{AB} = \frac{1.858x10^{-27} T^{3/2}}{P\sigma^2{}_{AB}\Omega_D}\left(\frac{1}{M_A} + \frac{1}{M_B}\right)^{0.5}$$

$D_{AB,T_2} = D_{AB,T_1}\left(\frac{T_2}{T_1}\right)^{3/2}\frac{\Omega_{T1}}{\Omega_{T2}}$; $\frac{kT_2}{\varepsilon_{AB}}, \Omega_{D_2} = 1.082$

(b) Using the equation of Wilke and Chang, determine the diffusivity at low concentration for the following diffusing pairs at 25°C

(i) methanol-water
(ii) ethanol water

$$D^{o}_{AB} = \frac{1.17x10^{-13}(\varepsilon_B M_B)^{0.5}T}{V_A^{0.6}\mu}$$

$\varepsilon_B = 2.6$; $M_B = 18$

$\mu = \mu_B(25°C) = 0.89cP(mPa.s)$

V_A(methanol) = 0.037

V_A(ethanol) = 0.0592

END OF QUESTION PAPER!!!