NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCE

DEPARTMENT OF APPLIED CHEMISTRY

TRANSPORT PHENOMENA

SCH 2108

First Semester Examination Paper

December 2014

This examination paper consists of 4 pages

Time Allowed: 3 hours
Total Marks: 100
Special Requirements: None
Examiner's Name: Mr. B. Nyoni

INSTRUCTIONS

1. Answer all questions in Section A and any other three questions from Section B
2. Each question carries 20 marks
3. Show steps clearly in any calculation
4. Start the answers for each question on a fresh page
5. Use of calculators is permissible

MARK ALLOCATION

QUESTION	MARKS
1.	**20**
2.	**20**
3.	**20**
4.	**20**
5.	**20**
TOTAL	**100**

SECTION A

1 (a) What do you understand by the following terms:

(i) Transport phenomena

(ii) Fluid statics

(iii) Heat transfer

(iv) Mass transfer

(v) Diffusion [10]

(b) What are the physical meanings of the following dimensionless groups:

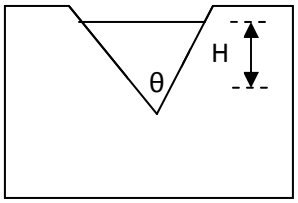
(i) Reynolds number

(ii) Prandtl number

(iii) Nusselt number [10]

2 (a) What is a *'dimensionally consistent equation'*. [4]

(b) The discharge flowrate (Q) of a triangular weir shown is given by the equation.



$$Q = \frac{8}{15} C_d \sqrt{2g} \tan\left(\frac{\theta}{2}\right) H^{\frac{5}{2}}$$

where: C_d – dimensionless discharge coefficient

g – acceleration due to gravity (m/s^2)

θ – notch angle

H – head of water over invert weir

Check the dimensional consistency of the given equation. [12]

(c) What is the flow rate in litres per second (L/s) given the following information?

$C_d = 0.6$
$g = 9.81\ m/s^2$
$\theta = 90^0$
H= 0.22m [4]

SECTION B

3 (a) Define the following terms;

i) Viscosity
ii) Density [4]

(b) Describe and explain the difference between a Newtonian and non-Newtonian fluid and give an example of each. [6]

(c) Prove that the resistance (F) of a sphere with diameter (D) moving at a constant speed (u) through a fluid of density (ρ) and viscosity (μ) is given by

$$F = \left(\frac{\mu}{\rho^2}\right) f\left(\frac{\rho u D}{\mu}\right)$$ [10]

4 (a) Derive the basic equation of fluid statics [8]

(b) Briefly describe how a manometer operates. [4]

(c) Consider an open tank of height **h**. If a hole is drilled at the bottom of the tank full of water of density **ρ**, use the Bernoulli's equation to show that the velocity at the exit of the hole is given by: $u = \sqrt{(2gh)}$ [8]

5 (a) Discuss the three mechanisms of heat transfer and give practical examples of each. [6]

(b) Describe any two heat exchanger types of your choice. [4]

(c) In Kern's method of designing (thermal design) of an exchanger to sub-cool condensate from a methanol condenser from 95 ^oC to 40 ^oC. The questions that follow are part of the steps in the design calculations.

The flow-rate of methanol in a pipe is 100 000 kg/h. Brackish water is used as the coolant, with a temperature rise from 25^{o}C to 40^{o}C.

Heat capacity of methanol = 2.84 kJ/kg^{o}C
Heat capacity of water = 4.2 kJ/kg^{o}C
U = 600 W/m^{2o}C

Calculate:

(i) The heat load
(ii) Cooling water flow
(iii) ΔT_m
(iv) The heat exchanger provisional area. [10]

6 (a) State the following;
(i) Two film theory
(ii) Fick's law of diffusion [6]

(b) Describe any two mass transfer equipment of your choice. [4]

(c) A mixture of He and N_2 is contained in a pipe at 298K and 1 atm total pressure which is constant throughout. At one end of the pipe at Point 1, the partial pressure P_{A1} of He is 0.60 atm and at the other end 0.2 m, P_{A2} is 0.20 atm. Calculate the flux of He if D_{AB} is 0.687 x 10^{-4}m^2/s.
R = 82.057m^{3}atm/kmolK. [10]

End of Question Paper!!!