NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF APPLIED CHEMISTRY

TRANSPORT PHENOMENA

SCH 2108

End of First Semester Examination Paper

December 2015

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
6.	20
TOTAL POSSIBLE MARKS	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 meaning 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) Check the dimensional consistency of the following empirical equation for a heat-transfer coefficient.

$$h_i = 0.023G^{0.8}k^{0.67}c_p^{0.33}D^{-0.2}\mu^{-0.47}$$

given

h_i = heat transfer coefficient (W/m^2.^{o}C)
G = mass velocity (kg/s.m^2)
k = thermal conductivity (W/m.^{o}C)
c_p = specific heat (J/g.^{o}C)
D = diameter
μ = absolute viscosity (kg/m.s) [12]

(c) What is the heat transfer coefficient, given the following data:

G = 54 kg/s.m^2
k = 0.12 W/m.^{o}C
c_p = 4.2 J/g.^{o}C
D = 0.11 m
μ = 0.034 kg/m.s [4]

SECTION B

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

(b) It is known that the power required to drive a fan depends upon the impeller diameter (D), the impeller rotational speed (ώ), the fluid density (ρ), and the volume flow rate (Q). (Note that the fluid viscosity is not important for gases under normal conditions.)

(i) Construct a table showing the variables, their respective symbols and fundamental dimensions required to define all of these variables. [4]

(ii) How many dimensionless groups are required to determine the relationship between the power and all the other variables? [2]

(iii) Find these groups in (ii) above by dimensional analysis, and use the Rayleigh's method of indices to arrange the relationship so that the power and the flow rate each appear in only one group. [8]

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) Kern's method is used for designing (thermal design) an exchanger to sub-cool condensate from a methanol condenser from 95 ^{o}C to 40 ^{o}C. The questions that follow are part of the steps in the design calculations.

The flow-rate of methanol 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
Temperature correction, F_t = 0.88

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) Fourier's law of heat conduction
(ii) Fick's law of diffusion [6]

(b) A tube or bridge of a gel solution of 1.05 wt% agar in water is at 278K and is 0.04m long. It connects two agitated solutions of urea in water. The urea concentration in the first solution is 0.2 mol/litre and is 0 in the other. $D_{AB} = 0.727 \times 10^{-9}\ m^2/s$.

(i) Draw a diagram of the described setup
(ii) Calculate the flux of the urea in $kmol/m^2s$ at steady state. [14]

End of Question Paper!!!