NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF APPLIED CHEMISTRY

TRANSPORT PHENOMENA

SCH 2108

First Semester Examination Paper

December 2016

This examination paper consists of 5 pages

Time Allowed:	**3 hours**
Total Marks:	**100**
Special Requirements:	
Examiner's Name:	**Dr E Sanganyado**

INSTRUCTIONS

1. Answer ALL questions from Section A and Any Three (3) questions from Section B.

MARK ALLOCATION

QUESTION	MARKS
SECTION A:	40
SECTION B: 5.	20
6.	20
7.	20
8.	20
TOTAL POSSIBLE MARKS	**100**

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Answer all questions

1. The power required by an agitator in a tank is a function of the following four variables:

   (a) diameter of impeller,
   (b) number of rotations of the impeller per unit time,
   (c) viscosity of liquid,
   (d) density of liquid.

   a. From a dimensional analysis, obtain a relation between the power and the four variables. [5 marks]

   b. The power consumption is found, experimentally, to be proportional to the square of the speed of rotation. By what factor would the power be expected to increase if the impeller diameter were doubled? [5 marks]

2. 98% sulphuric acid of viscosity 0.025 N s/m^2 and density 1840 kg/m^3 is pumped at 685 cm^3/s through a 25 mm line.

   a. Calculate the value of the Reynolds number. [3 marks]

   b. What is the type of flow of this sulphuric acid? [1 marks]

   c. What type of pump would you recommend for this fluid and why? [2 marks]

   d. To improve the flow of sulphuric acid, a process engineer proposes decreasing the viscosity of the fluid. Describe what measures you would take to decrease the viscosity. [4 marks]

3. A cooling coil, consisting of a single length of tubing through which water is circulated, is provided in a reaction vessel, the contents of which are kept uniformly at 360 K by means of a stirrer. The inlet and outlet temperatures of the cooling water are 280 K and 320 K respectively.

   a. What would be the outlet water temperature if the length of the cooling coil were increased by 5 times? Assume the overall heat transfer coefficient to be constant over the length of the tube and independent of the water temperature. [4 marks]

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b. PEI is a thermoset plastic with operating conditions above 350 K. Eng. Ben Chimuti recommended using PEI as the material for the cooling coil. Instead of coiling the cooling system he proposed using a cylindrical ring to cut costs.

    i. Do you agree with his recommendation and why?   [4 marks]

    ii. Give two examples of materials you would use for the cooling coil.

    [2 marks]

4. A simple rectifying column consists of a tube arranged vertically and supplied at the bottom with a mixture of benzene and toluene as vapor. At the top, a condenser returns some of the product as a reflux which flows in a thin film down the inner wall of the tube. The tube is insulated and heat losses can be neglected. At one point in the column, the vapor contains 70 mol% benzene and the adjacent liquid reflux contains 59 mol% benzene. The temperature at this point is 365 K. Assuming the diffusional resistance to vapor transfer to be equivalent to the diffusional resistance of a stagnant vapor layer 0.2 mm thick, calculate the rate of interchange between vapor and liquid of

    a. Benzene   [5 marks]

    b. Toluene   [5 marks]

The molar latent heats of the two materials can be taken as equal. The vapor pressure of toluene at 365 K is 54.0 kN/m^2 and the diffusivity of the vapors is 0.051 cm^2/s.

Answer <u>any three</u> questions.

5. Tobacco farming has been shown to cause environmental pollution. Using your knowledge of transport phenomena explain how pesticides enter the environment. Your discussion should include the basic concepts of transport phenomena, relevant equations and include diagrams were possible.   [20 marks]

6. Due to climate change, Bulawayo like many cities in Sub Saharan Africa is facing a serious water crisis. The Zambezi Water Project sought to mitigate the problem by constructing a water pipeline from Zambezi River to a proposed new dam in Bulawayo. Using your knowledge of transport phenomena, discuss the type of equipment you would use to ensure water flows from Zambezi River to the new dam. What factors would you consider in the selection of the equipment?

[20 marks]

7. Recently, Los Angeles City dumped more than 90 million black plastic balls into its water reservoir to minimize water loss due to evaporation. Using graphs and any other appropriate drawings, discuss how the water balls would minimize the water loss. What other method would you recommend to minimize water loss due to evaporation in reservoirs and why?

[20 marks]

8. Show *all* your working.
   a. A refractory material with an emissivity of 0.40 at 1500 K and 0.43 at 1420 K is at a temperature of 1420 K and is exposed to black furnace walls at a temperature of 1500 K. What is the rate of gain of heat by radiation per unit area?

[7 marks]

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b.   An adult takes an acetaminophen dose of 1200 mg per day. If the body size of a child is one third that of an adult, using dimensional analysis determine the daily dose you would recommend for a child.

[5 marks]

c. A 50 mm diameter pipe of circular cross-section and with walls 3 mm thick is covered with two concentric layers of lagging, the inner layer having a thickness of 25 mm and a thermal conductivity of 0.08 W/m K, and the outer layer a thickness of 40 mm and a thermal conductivity of 0.04 W/m K. What is the rate of heat loss per metre length of pipe if the temperature inside the pipe is 550 K and the outside surface temperature is 330 K?

[8 marks]

END OF QUESTION PAPER!!!