NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
BACHELOR OF SCIENCE HONOURS DEGREE
SUPPLEMENTARY EXAMINATIONS – AUGUST 2014
TRANSPORT PHENOMENA – SCH 2108
TIME: 3 HOURS

INSTRUCTIONS TO CANDIDATES

1. Answer all questions in Section A and any three questions in Section B.
2. Show all your steps clearly in any calculation.
3. Start the answers for each question in a new page.

SECTION A

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

(i) Fundamental dimensions

(ii) Derived dimensions

(iii) Viscosity

(iv) Thermal resistance

(v) Equi-molar counter diffusion [10]

(b) What are the physical meanings of the following dimensionless groups, give a practical application of each of them:

(i) Reynolds number

(ii) Prandtl number

(iii) Nusselt number [10]

2 (a) Describe and explain the difference between a Newtonian and non-Newtonian fluid and give an example of each. [4]

(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 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. [10]

<u>SECTION B</u>

3 (a) What do you understand by the term *'a dimensionally consistent equation'*. [3]

(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 ($W/m^2.^oC$)
G = mass velocity ($kg/s.m^2$)
k = thermal conductivity ($W/m.^oC$)
c_p = specific heat ($J/g.^oC$)
D = diameter
μ = absolute viscosity (kg/m.s) [14]

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

$G = 54$ $kg/s.m^2$
$k = 0.12$ $W/m.^oC$
$c_p = 4.2$ $J/g.^oC$
$D = 0.11$ m
$\mu = 0.034$ kg/m.s [3]

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

(b) A manometer containing an oil with a specific gravity (SG) of 0.97 is connected across an orifice plate in a horizontal pipeline carrying seawater (SG = 1.3). If the manometer reading is 19.8 cm, what is the pressure drop across the orifice in Pa. [6]

(c) A diffuser is a section is a section in a conduit over which the flow area increases gradually from upstream to downstream. The inlet and outlet areas are 0.002 and 0.004m^2 respectively, and the upstream pressure is 40kPa and velocity is 2 m/s. The fluid is incompressible and has a specific gravity 0.95. Using the *Continuity and Bernoulli Equations* calculate:

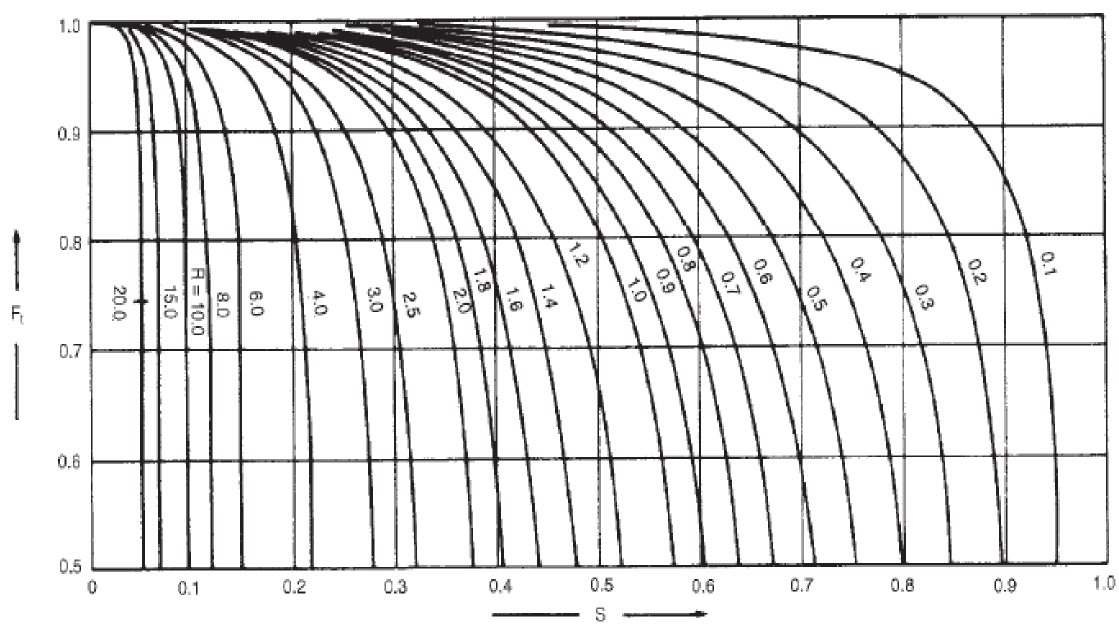
(i) the downstream velocity
(ii) the downstream pressure [6]

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

(b) 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 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. [14]

6 (a) State the following;

(i) Two film theory

(ii) Fick's law of diffusion
and in each case give an example of its application [4]

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

(c) a hot combustion chamber, oxygen diffuses through an air film to a carbon surface where it reacts according to the following equation:

$3C + 2O_2 \longrightarrow 2CO + CO_2$, use a fully labeled diagram to answer the following questions.

(i) Reduce the general differential equation for mass transfer to write the specific differential equation that describes this process, assuming that the carbon surface is flat and the process is at steady state.

(ii) Write Fick's law in terms of only oxygen. [12]

END OF QUESTION PAPER!!!