NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
BACHELOR OF SCIENCE HONOURS DEGREE
END OF FIRST SEMESTER EXAMINATIONS – JANUARY 2011
TRANSPORT PHENOMENA – SCH 2108
TIME: 3 HOURS

INSTRUCTIONS TO CANDIDATES

Answer _all questions_ in Section A and _any 3_ questions in Section B. Total marks are 100.

SECTION A

1. (a) State the ***three*** fundamental laws of transport phenomena.   [3 marks]

   (b) Describe the difference between heat and temperature.   [5 marks]

2. (a) Define what is a fluid.   [3 marks]

   (b) Explain the difference between mass and weight.   [2 marks]

   (c) State what the following symbols represent.

              (i) psig

             (ii) psia

             (iii) psi   [3 marks]

3. (a) State the Bickingham Pi Theorem.   [2 marks]

   (b) Distinguish between a value, unit and dimension.   [3 marks]

   (c) Give ***three*** cases in which an expression is dimensionally inconsistent.

          [3 marks]

4. (a) Define the following terms as applied in heat transfer:

        (i) thermal conductivity.   [2 marks]

        (ii) bulk temperature.   [2 marks]

        (iii) log mean temperature difference of a heat exchanger.

                                                       [2 marks]

  (b) State and explain the principle of *any two* modes of heat transfer.

                                                       [2 marks]

5. A turbine located 200m below the water surface at intake has a flow rate of $15m^3/s$. The head loss due to friction in the pipe is 25m. Find the power produced by the turbine if it is 85% efficient.   [8 marks]

SECTION B

6. (a) Discuss the differences between the behaviour of solids and fluids under an applied force, with the aid of diagrams.   [4 marks]

  (b) Derive the continuity equation for an incompressible fluid.   [5 marks]

  (c) With the aid of a diagram, compare and contrast:

        (i) Thixotropic substances and rheopectic substances

        (ii) Bingham plastic and a plastic   [6 marks]

  (d) State the Pascal's Law. Give a detailed account of its industrial application in Zimbabwe.   [5 marks]

7. (a) With the aid of a diagram, describe the principle of operation of any *one* of the following:

      (i) u-tube viscometer.

      (ii) falling ball viscometer. [7 marks]

  (b) Calculate the stagnation pressure 5m below the surface of fluid of specific gravity 1.4 when it is moving at 5 m/s. [5 marks]

  (c) The following materials exhibit flow properties that can be described by models that include a yield stress (e.g., Bingham plastic): (a) toothpaste; (b) paint; (c) coal slurries; (d) printing ink. In terms of typical applications of these materials, describe how the yield stress is beneficial to their behavior, in contrast to how they would behave if they were Newtonian. [8 marks]

8. (a) List *four* types of heat exchangers. [4 marks]

  (b) From question 8 (a) choose any *one* type of heat exchanger and explain its principle of operation, with the aid of diagrams. In your discourse state:

      (i) Three factors that affect the performance of the heat exchanger.

      (ii) Two advantages of the heat exchanger.

      (iii) Two disadvantages of the heat exchanger. [10 marks]

  (c) Consider a composite structure shown on page 4. Conductivities of the layer are: $k_1 = k_3 = 10$ W/mK, $k_2 = 16$ W/mK, and $k_4 = 46$ W/mK. The convection coefficient on the right side of the composite is 30 W/m2K. Calculate the total resistance and the heat flow through the composite. [6 marks]

$T_1 = 100\ °C$

$T_\infty = 20\ °C$

$A_1 = A_2 = A_3 = 0.1\ m^2$

$A_4 = 0.03\ m^2$

$L_1 = 20\ cm,\ L_2 = L_3 = 15\ cm$
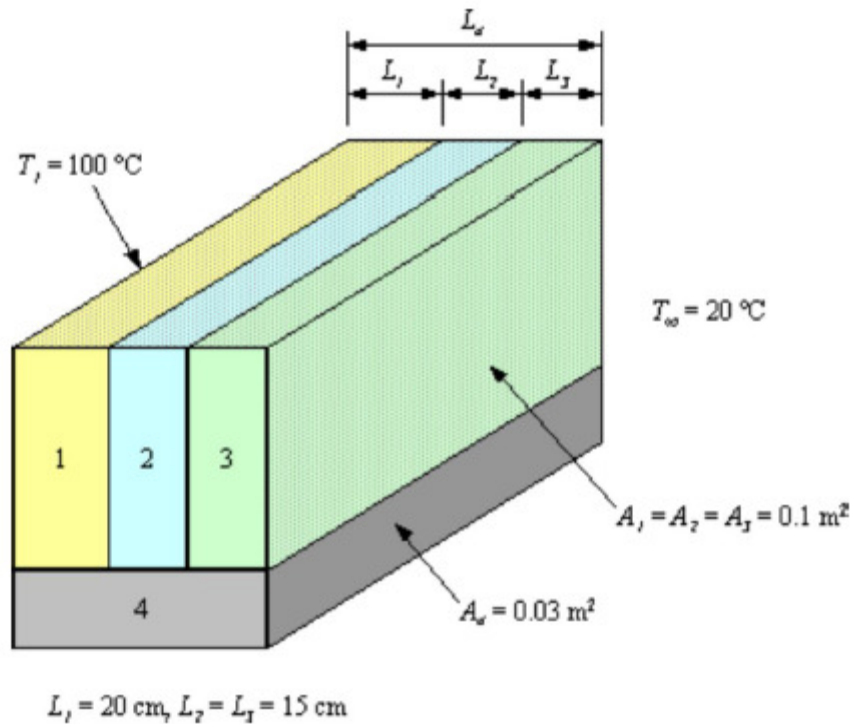
9. (a) State the Soret effect. [2 marks]

(b) List *four* different mechanisms of mass transfer other than ordinary diffusion.

[4 marks]

(c) Discuss *any five* characteristics of mass transfer. [10 marks]

(d) With the aid of a diagram explain Reynolds experiment and its importance in

characterizing the nature of flow of a fluid. [6 marks]

END OF QUESTION PAPER!!!