NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
END OF FIRST SEMESTER EXAMINATIONS – DECEMBER 2005
TRANSPORT PHENOMENA – SCH 2108
TIME: 3 HOURS

INSTRUCTION TO CANDIDATES

Answer **FIVE** questions only. Each full question carries 20 marks. Total marks are 100.

---

1. (a) Define what is called ***Shear Stress***. (2 marks)

   (b) By means of a diagram, or if you prefer by simply describing in words, how are fluids classified? (2 marks)

   (c) Explain the difference between the mass of an object and the weight of an object. (2 marks)

   (d) A Newtonian Fluid is one which, provided that the temperature and pressure remain constant, the shear rate increases linearly with shear stress over a wide range of shear rate.

      (i) Draw a fully labelled diagram that is conventionally used to illustrate this phenomenon, showing the relationship between ***Shear Stress*** and ***Shear Rate***. (4 marks)

      (ii) In the diagram you have just drawn, as required in d (i), indicate which is, or where lies:

      - Shear force (1 mark)
      - Velocity profile (1 mark)

      (iii) Write the mathematical relationship between ***Shear Stress*** and ***Shear Rate***. (4 marks)

      (iv) What term is used to describe the proportionality constant in the relationship that you have expressed above, under 1 d(iii), and what are the units of this quantity? (4 marks)

2. (a) Give ***three*** examples of systems where static pressure obtains? (3 marks)

   (b) What would you say is the basic property of a static fluid? (1 mark)

   (c) Given a stationary mass of a stationary fluid, where do you find the pressure being constant and how does that pressure vary? (2 marks)

(d) What does Newton's second law of motion say about a stationary body of fluid? Write the Law as an equation. (4 marks)

(e) Illustrate by means of a diagram the relations that exist among the following forms of pressure: (10 marks)

(i) Absolute pressure
(ii) Atmospheric pressure
(iii) Gauge pressure
(iv) Barometric pressure
(v) Vacuum pressure

(vi) Illustrate the relationship between vacuum pressure absolute pressure.

(vii) Write the mathematical expression that shows the relationship between ***Absolute Pressure***, ***Barometric Pressure*** and ***Gauge Pressure***.

3. (a) The large closed tank shown here, Fig. 1, is partly filled with benzene at 20°C. If the pressure on the surface is saturated, what is the absolute pressure of the benzene 3m below the liquid surface? (14 marks)

From a Table of: Critical and Saturated Properties of Selected Fluids, we get the following data (for 20°C): $P_v = 10.04$ kPa
$\rho = 877.7$ kg/m^3

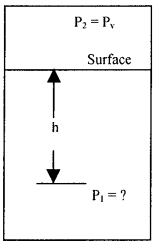

Fig. 1

NB: Assume standard gravity.

(b) In a plant you have purchased out of the United States, the following designations are used for values on the equipment:

(i) psi (1 mark)
(ii) psig (1 mark)
(iii) psia (1 mark)

Elucidate what each of the designations (i) to (iii) stand for.

(iv) What is the value of psi according to the British Engineering System of units and what is that equivalent to in the SI system of units? (3 marks)

4. Calculate the power required to pump H_2SO_4 acid of sg 1.84 and viscosity 25cp at 2 500cm^3/sec through a 50mm pipeline, 100m long, the outlet of which is 15m higher than the inlet. The efficiency of the pump is 60%. (20 marks)

For turbulent flow assume $f = 0.184\ Re^{-0.2}$

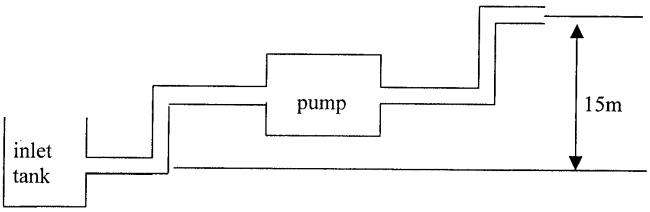

Fig. 2

Length of pipe L = 100m = 1000mm.

5. (a) Draw a diagram illustrating fully developed flow of solution through a tube of large cross section.

Label the diagram to show the following:

(i) Boundary layer (3 marks)
(ii) Laminar flow (3 marks)
(iii) Turbulent flow (3 marks)
(iv) Write an equation that defines the average velocity, ū, across the entire stream tube. (5 marks)
(v) What units are used to express average velocity? (1 mark)

(b) What does the Law of Conservation of Matter yield concerning flow through a stream tube? (2 marks)

(c) Draw a sketch and write an equation that puts the Law of conservation of matter into effect? (3 marks)

6. Water is flowing through a 50mm pipe orifice meter with 40mm aperture used to measure the flow of water. The recorded pressure drop is 25cm on a mercury under water manometer and the coefficient of discharge of the meter is 0.62.
Specific gravity of mercury is 13.6
Viscosity of water = 0.3cp

(a) Calculate the velocity, U_o, at the orifice plate? (10 marks)

(b) What is the Reynold's number in the pipe? (10 marks)

7. (a) A thin rectangular plate having a width, w, and a length, l, is located so that it is normal to a moving stream of fluid. Assume the drag, Ð, that the fluid exerts on the plate is a function of width and length, the fluid viscosity and density and ρ, respectively and the velocity, of the fluid approaching the plate. Determine a suitable set of pi terms to study this problem experimentally, using M, L, T and show all steps involved.

(15 marks)

(b) A capillary tube has an 8-mm inside diameter through which liquid fluorine refrigerant R-11 flows at a rate of $0.03cm^3/s$. The tube is to be used as a throttling device in an air conditioning unit. A model of this flow is constructed by using a pipe of 3cm inside diameter and water as fluid medium.

(i) What is the required velocity in the model for dynamic similarity?

Use Reynolds number and continuity concepts; Re(model)= Re(prototype), V=Q/A Viscosity of model = $0.89x10^{-3}$Pa.s, viscosity of prototype = $0.42x10^{-3}$Pa.s, Density of model =$1g.cm^3$, density of prototype = $1.48g/cm^3$.

(5marks)

End of question Paper!!!