NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES
BACHELOR OF APPLIED BIOLOGY AND BIOCHEMISTRY

Part II Examination JUNE 2004

SCH2218 - PRINCIPLES OF PROCESS ENGINEERING

Duration of Examination: 3 hours

Instructions to Candidates

1. Answer ANY five questions.
2. Start the answers for each question on a fresh page.

1. a) What is the heat content of tomato soup concentrate at 30°C above a reference of 0°C. The specific heat of the soup is 5.020 KJ/kgK? (3)

   b) i) The influence of temperature on the death rate of yeast cells is illustrated by the following experimental data.

Temperature °C	Rate Constant
105	0.00061
106	0.00114
110	0.00222
113	0.00412
116	0.00758

   Determine the activation energy E_a and the pre-exponential factor (frequency factor) (10)

   ii) Explain in detail with the aid of a diagram what is really meant by activation energy. (7)

2. a) A tube viscometer with 0.267cm diameter and 0.91m length was used to obtain the following data for apple sauce. Find the rheological parameters. (10)

$\Delta P(10^5 X$ Pa)	$(10^{-1}$ $m^3 s)$
1.30	0.91
1.45	2.50
2.56	2.10
1.99	3.20
2.13	5.20
2.41	8.50
2.70	12.49

b) Discuss the Maxwell and Kevin viscoelastic models. (10)

3. a) What are material balances used for? (3)

b) Outline the general suggested procedure for performing a material balance calculation. (5)

c) State any four reasons for recycling in process industries. (4)

d) A mixture containing 45% Benzene and 55% Toluene T by mass is fed to a distillation column. An overhead stream of 95% weight B is produced and 8% of benzene leaves in the bottom stream. The flow rate of the fixed stream is 2000kg/hr. Draw a flow diagram for the process and show the stream compositions and flow rates. (8)

4. a) With the aid of diagrams describe the three models of heat transfer. (6)

b) What is a heat exchanger? (2)

c) How can heat exchangers be classified? (2)

d) A thick walled steel pipe, thermal conductivity 19 W/mK, 20mm internal radius and 40mm outside radius is covered with a 30mm layer of insulation of thermal conductivity 0.2 W/mK. If the inside wall temperature of the pipe is 500°C and the outside temperature of the insulation is 50°C. Calculate the heat loss per unit length. (7)

5. a) With the aid of a diagram describe the rate of drying. (10)

b) A wet solid is dried from 25% moisture under constant drying condition for 15ks (417 h). If the critical and equilibrium moisture content are 15

and 5 percent respectively, how long will it take to dry the solid from 30 to 8 percent moisture under the same conditions? (10)

6. a) Explain what is meant by boiling point elevation and phase change. (5)

b) Why should we evaporate our food products? (5)

c) 14.4 tonne per hour (4kg/s) of liquor with 10% solids is fed at 294 K to the first effect of a triple effect unit. Liquor with 50% pressure is to be withdrawn from the third effect, which is at a pressure of 0.13 bar (13 KN/m^2). The liquor will be assumed to have a specific heat capacity of 4.18 KJ/kgK and to have no BPR. Saturated dry steam at 205 KN/m^2 is fed to the heating element of the first effect and the condensate is removed at the steam temperature in each effect. If the three units are to have equal areas, estimate the area, the temperature, the temperature differences and the steam consumption. Assume heat transfer coeffients of 3.1, 2.0 and 1.0 KW/m^2K for the first, second and third effects respectively. (10)

7. a) Briefly discuss the factors which affect the rate of leaching. (8)

b) A counter current extraction system is being used to extract oil from 1000kg soya beans per hour. The system is to be designed to extract oil from soya beans with 18% oil and provide 40% oil in the extract solution leaving at 800kg per hour. If the weight of the extract solution in solids leaving the system is equal to 50% of the weight of solids, compute the composition of stream containing solids leaving the first stage and the composition of solvent entering stage I. (12)

8. a) A filtration system is being designed to filter $4m^3$ of a slurry in 2 hours using a constant pressure of 400Kpa. The necessary design conditions were established on a laboratory scale using a filter with $0.1m^2$ surface area and 140 Kpa constant pressure. The following results were obtained on a laboratory scale.

Filtration Volume $10^{-2} \times m^3$	Time (mins)
2.3	10
3.7	20
4.9	30
6.1	40
6.8	50

Determine the filter area required in the design situation which will provide the desired conditions (6)

b) A liquid is being filtered at a pressure of 200Kpa through $0.2m^2$ of filter. Initial results indicate that 5 minutes is required to filter $0.3m^3$ of liquid. Determine the time will elapse until the rate of filtration drops to 5×10^{-5} m^3/s. (5)

c) Briefly discuss the following mechanical separation processes:

i) Filtration (3)
ii) Centrifugation (3)
iii) Sedimentaion (3)

). a) A solution with a viscotiy of 1.2 Nsm^{-2} and specific gravity of 1.21 flows at a rate of 0.031^3 5^{-1} in a pipe of 254 mm diameter Determine whether the flow is laminar. What should be the minimum flow rate to produce turbulent flow. (7)

b) Sulphuric acid is pumped through a steel pipe 0.025m diameter and 150m long at the rate of 2.52 kgs^{-1}. Given the following data;

Viscocity of acid = 25×10^{-3} Nsm^{-2}
Density of acid = 1840 Kgm^{-3}
F = 0.04

Calculate the friction loss in the pipe. (7)

c) Assume the frictionless flow in a horizontal conical pipe the diameter of which is 0.6 m at one end and 1.2m at the smalter and the head is 4.9 m of water. If water flows through this pipe at the rate of $3.56m^{-3}s^{-1}$, calculate the pressure head at the larger end. (6)