

**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**FACULTY OF APPLIED SCIENCES  
BACHELOR OF APPLIED CHEMISTRY**

**Part II Examination June 2004**

**SCH2208 - UNIT OPERATIONS**

**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.

<u>Temperature °C</u>	<u>Rate Constant</u>
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) 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)
3. 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)
4. 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 Liquor with 50% pressure is to be withdrawn from the third effect, which is at a pressure of 0.13 bar (13 KN/m<sup>2</sup>). 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<sup>2</sup> 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 coefficients of 3.1, 2.0 and 1.0 KW/m<sup>2</sup>K for the first, second and third effects respectively. (10)
5. 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)
- 6 a) A filtration system is being designed to filter 4m<sup>3</sup> 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  $0.1\text{m}^2$  surface area and 140 Kpa constant pressure. The following results were obtained on a laboratory scale.

<u>Filtration Volume <math>10^{-2} \times \text{m}^3</math></u>	<u>Time (mins)</u>
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  $0.2\text{m}^2$  of filter. Initial results indicate that 5 minutes is required to filter  $0.3\text{m}^3$  of liquid. Determine the time will elapse until the rate of filtration drops to  $5 \times 10^{-5} \text{m}^3/\text{s}$ . (5)
- c) Briefly discuss the following mechanical separation processes:
- i) Filtration (3)
  - ii) Centrifugation (3)
  - iii) Sedimentaion (3)
7. a) Discuss the factors which affect the rate of leaching. (6)
- b) A single stage extraction system is being used to extract oil from cod liver. The feed rate into the extractor is  $1000\text{kg}/\text{hr}$  and the solvent contains 0.99 mass fraction ether and 0.01 mass fraction oil. The cold liver feed contains 0.326 mass fraction oil and 0.674 mass fraction solids. If a mass fraction of 0.83 oil is desired in the exit extract with a maximum of 0.579 mass fraction solids will be allowed in the exit stream carrying solids, determine the rate at which the solvent will be required. (7)
- c) In the manufacture of vinyl chrolide VC by the pyrolysis of dychloroethane (DCF), the reactor conversion is limited to 55% to reduce carbon formation which fouls the reactor tubes. Calculate the quantity of DCE needed to produce  $500 \text{Kf}/\text{hr}$  VC. (3)
- d) In a test on a furnace fired with natural gas (composition 95% methane, 5% nitrogen) the following fine gas analysis was obtained;

Oxygen 4.6%  
Nitrogen 86%  
Carbon dioxide 9.1%  
Carbon monoxide 0.2%

All percentages are by volume. Calculate the percentage excess airflow.  
(3)