

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
END OF SEMESTER EXAMINATIONS – MAY 2003
PRINCIPLES OF PROCESS ENGINEERING – SCH 2218
TIME – (3) THREE HOURS

INSTRUCTIONS TO CANDIDATES

Answer **ANY FIVE** questions. Start each question on a fresh page.

QUESTION 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 marks)
- (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 marks)

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

QUESTION 2

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

$\Delta P (10^5 \times \text{Pa})$	$(10^{-1} \text{ m}^3 \text{ s})$
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

$$Q = \pi \left[\frac{\Delta p}{2ML} \right]^{\frac{1}{n}} \left(\frac{n}{3n+1} \right) R^{(3n+1)/n}$$

- 2(b) Discuss the Maxwell and Kelvin viscoelastic models. (10 marks)

QUESTION 3

- (a) What are material balances used for? (3 marks)
- (b) Outline the general suggested procedure for performing a material balance calculation. (5 marks)
- (c) State any four reasons for recycling in process industries. (4 marks)
- (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 marks)

QUESTION 4

- (a) With the aid of diagrams, describe the three modes of heat transfer. (6 marks)
- (b) What is a heat exchanger? (2 marks)
- (c) How can heat exchangers be classified? (5 marks)
- (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 marks)

QUESTION 5

- (a) With the aid of a diagram, describe the rate of drying. (10 marks)
- (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% respectively, how long will it take to dry the solid from 30 to 8% moisture under the same conditions. (10 marks)

QUESTION 6

- (a) Explain what is meant by boiling point elevation and phase change. (5 marks)
- (b) Why should we evaporate our food products? (5 marks)

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- (c) 14.4 tonne per hour (4kg/s) of liquor with 10% solids is fed at 294K to the first effect of a triple effect unit. Liquor with 50% solids is to be withdrawn from the third effect, which is at a pressure of 0.13 bar (13 KN/m²). 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/m² 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/m²K for the first, second and third effects respectively. (10 marks)

QUESTION 7

- (a) Briefly discuss the factors which affect the rate of leaching. (8 marks)
- (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 the stream containing solids leaving the first stage and the composition of solvent entering stage 1. (12 marks)

END OF PAPER!!!

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