UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualifications:-

B.Eng. *M.Eng.*

Chemical Eng E869: Particulate Systems and Separation Processes

COURSE CODE	:	**CENGE869**
UNIT VALUE	:	**0.50**
DATE	:	**25-MAY-04**
TIME	:	**10.00**
TIME ALLOWED	:	**3 Hours**

TURN OVER

Answer FOUR questions. **Only the first four answers will be marked.**
ALL questions carry a total of 20 MARKS each, distributed as shown [ ]

1.

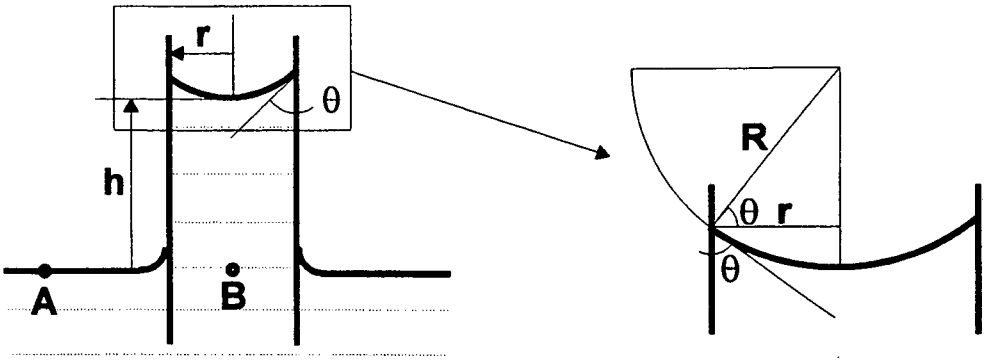
i) Give one brief definition of surface or interfacial tension. [3]

ii) The following table gives the surface tensions (in $mN.m^{-1}$) of the listed liquids at the liquid-air interfaces at 20 °C:

n-Heptane	20.1
Water	72.8
Mercury	485

Explain briefly why the surface tensions of these three liquids are so different. [5]

iii) The rise of a liquid in a capillary, shown below, is one of the most accurate ways of measuring surface tension:



r is the radius of the capillary
h is the height of the capillary rise
R is the radius of the spherical surface of the liquid meniscus
θ is the contact angle of the liquid with the wall of the capillary

By constructing a force balance at point B, or otherwise, and explaining your reasoning, show that the height of the capillary h is given by:

$$h = \frac{2\gamma \cos\theta}{\rho.g.r}$$

where ρ is the liquid density, g is the acceleration due to gravity, and γ is the surface tension at the liquid-air interface.

The weight of the liquid in the meniscus of the capillary, and the density of the ambient gas, may be assumed negligible. The rise in pressure at equilibrium on passing from the convex to the concave side of a curved surface of radius x is $\frac{2\gamma}{x}$. [8]

CONTINUED

iv) You are asked to use the method shown in (iii) to determine surface tension. Describe, with explanations, what conditions you would select in order to obtain optimum accuracy of your measurement? [4]

2.

i) Two of the main desired attributes of membranes are high permeability and high selectivity. Define *permeability* and *selectivity.* [2]

ii) A solvent mixture used in a crystallisation process contains isopropanol with some water. In order to recycle the isopropanol back to the crystallisation stage, the water must be removed. A batch pervaporation unit is designed to concentrate the isopropanol from 90 vol% to 99.5 vol%, i.e. only 0.5 vol% water remaining. The unit has an initial volume of 1 m^3 and the membrane area is 1.5 m^2. Assume that the membrane has a retention of 75% for isopropanol with reference to the initial feed concentration. From laboratory trials, it has been found that the flux through the membrane is 100 litre m^{-2} hr^{-1}.

a) Draw a sketch of the process. [2]

b) Find the permeate concentration (vol%) and the permeate and retentate volumes (m^3) at the end of the batch. [6]

c) Calculate the batch processing time t_{batch} (hr). [3]

d) What is the percentage loss of isopropanol for the process? [2]

iii) Define chromatography. Discuss briefly ways in which a chromatographic process can be made more efficient. [5]

3.

Explain how the size of a non-spherical particle may be expressed in terms of an equivalent spherical particle. [5]

Define the terms:

a) Equivalent aperture size,
b) Equivalent spherical diameter,
c) Surface shape factor,
d) Volume shape factor,
e) Specific surface shape factor, and
f) Specific surface area [5]

CONTINUED

Rectangular particles 200 μm long and 20 μm x 10 μm in square cross-section are produced in a crystallization process. Calculate:

i) The equivalent spherical volume diameter of the crystals,
ii) Their corresponding surface shape factor,
iii) Their volume shape factor,
iv) Their specific surface shape factor, and
v) Their specific surface area. [10]

4.

Explain with the aid of a sketch how a rotary vacuum (ROVAC) filter works. [5]

Derive describing equations to predict the ROVAC's filtration performance in terms of volume of filtrate and filter cake obtained, respectively. [5]

A continuous ROVAC filter is fitted with a two speed gear box. If the drum rotates at 0.1 Hz, a filtrate flowrate of 0.02 m^3s^{-1} is achieved.

If the second gear doubles the shaft speed, calculate the consequent effect on:

a) filter cake production rate [5]

b) filter cake thickness. [5]

[Neglect the resistance of the filter medium and assume that the cake is incompressible.]

5.

Describe the motion of a solid particle settling in a liquid and discuss the effect on it of applying a centrifugal force. [5]

Define the terms *Separating Effect*, G, and *Sigma Factor*, Σ, as applied to centrifuges, and explain their meaning. [5]

Derive simple expressions for G and Σ for a thin cylindrical solid bowl centrifuge, carefully stating any assumptions that you may make. [5]

Estimate the magnitude for a machine 2 m long by 0.5 m in diameter operating with a liquid depth of 0.05 m and rotating at 100 Hz. [5]

END OF PAPER