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 : **13-MAY-05**

TIME : **10.00**

TIME ALLOWED : **3 Hours**

05-C0193-3-60

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) Explain briefly what is meant by the term 'colloidal dispersion'. [3]

(ii) Colloidal dispersions may be stable or unstable. What underlying physical principle determines whether or not a dispersion will be stable? Describe briefly the principal interactive forces that determine sol stability for the simple case of a lyophobic sol dispersed in an electrolyte. [5]

(iii) By means of a diagram of interaction potential energy against particle separation distance, or otherwise, show how these forces of stabilisation and destabilisation interact to determine stability for the cases of a stable and an unstable sol. Show also the conditions at the stability threshold and write down a simple mathematical formulation of the threshold criteria. [6]

(iv) The zeta (ζ) potential is a quantity that is easy to measure for suspended sol particles, and its value can give a good indication as to whether the sol will be stable or unstable. Explain why this is so, and how you would expect high and low zeta potentials to correlate with stability or instability. [6]

2.

(i) Define Chromatography. Discuss briefly the separation mechanisms for the following two chromatographic processes:

1. Reverse Phase Bonded-Phase Chromatography (RP-BPC)
2. Hydrophobic Interaction Chromatography (HIC)

[6]

(ii) Membranes are used extensively in air separation to produce oxygen and/or nitrogen. Consider a process which is to produce a product permeate stream q_p of 10 m^3 hr^{-1} of oxygen-enriched air in a single pass system with a minimum oxygen concentration $x_{p,O2,min}$ of at least 35%. The process is to be carried out using a vacuum pump on the permeate side. The air flowrate q_f can be assumed to be 20 times that of the permeate and the air is to be pumped into the membrane using a blower. The absolute upstream pressure P_{up} is 1 bar and the absolute downstream pressure P_{down} is 0.15 bar.

Two composite membranes A and B are available with selectivities $P_{O2/N2}$ of 2.2 and 1.85, respectively. Determine the achievable permeate concentration $x_{p,O2}$ for each membrane. [2]

CONTINUED

(iii) The performance of each membrane was tested in a 7.5cm diameter circular test cell by measuring the flux through the membrane as a function of the absolute downstream pressure with the upstream pressure constant at 1 bar. The results are given below.

Downstream Pressure bar	**Membrane A Flux $cm^3\ hr^{-1}$**	**Membrane B Flux $cm^3\ hr^{-1}$**
0.10	1147	1564
0.15	1025	1419
0.20	903	1273
0.25	780	1127
0.30	658	982

Plot the flux as a function of downstream pressure for each membrane on the same graph.

The flux is given by

$$J_{O2} = P_{O2}\,(p_f - p_p)$$

where J_{O2} is the flux through the membrane ($m^3\ m^{-2}\ hr^{-1}$), P_{O2} is the permeability ($m^3\ m^{-2}\ hr^{-1}\ bar^{-1}$) and p_f and p_p are the partial pressures of feed and retentate, respectively (bar).

Determine the oxygen permeability P_{O2} of each membrane. [6]

(iv) Which membrane would you recommend to use for the process and why? [2]

(v) Find the required membrane area for the membrane selected in part iv). [4]

3. Define the terms:

(a) Equivalent aperture size,

(b) Equivalent spherical diameter,

(c) Surface shape factor,

(d) Volume shape factor, and

(e) Specific surface area.

[10]

CONTINUED

Coal dust approximating to spheres 200 μm in diameter is to be reconstituted as pellets approximating to rods 1.5cm long and 0.5 cm in diameter for burning in a fluidised bed combustor. Calculate:

(i) The equivalent volume diameter of the rods.

(ii) Their corresponding surface and volume shape factors, and,

(iii) The relative change in outer specific surface area on forming the fuel expressed on a solids volume basis. [10]

4.

Describe how a batch filter press works and derive describing equations based on Darcy's Law for operation at:

a) Constant pressure and
b) Constant rate. [10]

A new particulate fine chemical process has been developed and it is proposed to use an existing batch filter to separate the solid from slurry. A laboratory batch filter 'leaf' test was carried out on a sample of slurry with the following results:

Time (s)	Filtrate ($m^3 \times 10^{-6}$),
0	0
390	300
850	500
1140	600

Test filter area = 0.05 m^2
Vacuum applied = 25.0 kN/m^2.

If the full-scale filter has an area of 6 m^2 and is operated at constant rate for 10 minutes after which time the pressure drop is 250 kN/m^2 and is maintained at that pressure for a further 30 minutes, calculate the expected:

(i) Initial filtration rate (L/minute) during the first period,

(ii) Average filtration rate (L/minute) over both periods, and

(iii) Final filtration rate (L/minute) at the end of the second filtration period. [10]

PLEASE TURN OVER

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 of G and Σ for a machine 1 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