UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualifications:-

B.Eng. *M.Eng.*

Chemical Eng E866: Introduction to Chemical Engineering

COURSE CODE	:	**CENGE866**
UNIT VALUE	:	**0.50**
DATE	:	**07-MAY-03**
TIME	:	**10.00**
TIME ALLOWED	:	**3 Hours**

03-C0195-3-70

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*Answer **FOUR QUESTIONS.*** **Only the first four answers given will be marked.**
***ALL** questions carry a total of **25 MARKS** each, distributed as shown* [ ]

All pressures are absolute unless otherwise stated.
R=8.314 J/mol K. 1 atm = 760 mm Hg. g = 9.81 m/s^2

1.

Fresh air containing 4.00 mole% water vapour is to be cooled and dehumidified to a water content of 1.70 mole% H_2O. A stream of fresh air is combined with a recycle stream of previously dehumidified air and passed through the cooler. The blended stream entering the unit contains 2.30 mole% H_2O. In the air conditioner, some of the water in the feed stream is condensed and removed as liquid. A fraction of the dehumidified air leaving the cooler is recycled and the remainder is delivered to a room. Taking 100 mol of dehumidified air delivered to the room as a basis of calculation, calculate the moles of fresh feed, moles of water condensed and moles of dehumidified air recycled. [25]

2.

Methane is burned with air in a continuous steady-state combustion reactor to yield a mixture of carbon monoxide, carbon dioxide and water. The reactions taking place are:

$$2\,CH_4 + 3\,O_2 \rightarrow 2\,CO + 4\,H_2O$$
$$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$$

The feed to the reactor contains 7.80 mole% CH_4, 19.4% O_2 and 72.8% N_2. The percentage conversion of methane is 90.0% and the gas leaving the reactor contains 8 mol CO_2/mol CO. Carry out a degree-of-freedom analysis on the process and calculate the molar composition of the product stream. [25]

3.

Five hundred kilogramme per hour of steam drives a turbine. The steam enters the turbine at 44 atm and 450 °C at a linear velocity of 60 m/s and leaves at a point 5 m below the turbine inlet at atmospheric pressure and a velocity of 360 m/s. The turbine delivers shaft work at a rate of 70 kW and the heat loss from the turbine is estimated to be 4 x 10^7 J/h. Calculate the specific enthalpy change associated with the process.

[25]

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4.

A fluid having density "ρ" and velocity "u" flows in a pipeline of length "l" in which bends and control valves are also present. Explain what is meant by "equivalent pipe length, l_e" and its significance in the calculation of the total frictional losses in the pipeline. [6]

Write the expression for the total frictional losses "ΔP_f" in the pipeline for turbulent flow. Use "c_f" and "d" to denote the Fanning friction coefficient in the pipeline and the pipe internal diameter respectively. [4]

2.32 $m^3 h^{-1}$ of water is pumped in a 35 mm internal diameter pipe through a distance of 125 m in a horizontal direction and then up through a vertical height of 12 m. The friction loss in the 90° square elbow may be taken as equivalent to 60 pipe diameters. Also in the line there is a control valve and frictional losses may be taken equivalent to 200 pipe diameters. Calculate the total head "H" to be delivered by the pump. You may neglect entrance and exit effects. You may assume that for this pipe c_f=0.079$Re^{-0.25}$. Assume the water to flow in turbulent regime through the pipe. Density and viscosity of water in the pipe are 1000 kg m^{-3} and 0.65 mN s m^{-2} respectively. [8]

Under these conditions, calculate also the power "P" required by the pump to deliver "H". [7]

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5.

A liquid mixture of methanol and water at its bubble point containing 45 mole percent of methanol is to be separated by continuous distillation. The column is a fractionation column operating in conjunction with a total condenser and a partial reboiler.

The requirements of the column are that 500 kmol/h of 95 mol% methanol is to be produced as distillate and that the residue is 5 mol% methanol.

a) Calculate both the flowrate (kmol/h) of the feed required to meet the production rate and the flowrate of the residue. [4]

b) Assuming constant molar overflow and with the aid of the diagram supplied, *which must be attached inside your answer book*, use the McCabe-Thiele method to estimate:

i) The minimum reflux ratio, R_{min}, for the separation. [4]

ii) The number of theoretical stages for a reflux ratio $R=(L/D) = 1.5\ R_{min}$. [12]

c) Assuming constant molar overflow and $R = 1.5R_{min}$, calculate the internal liquid and vapour flowrates (kmol/h) above and below the feed tray. [5]

Data:
Diagram supplied showing vapour-liquid equilibrium curve for methanol and water.

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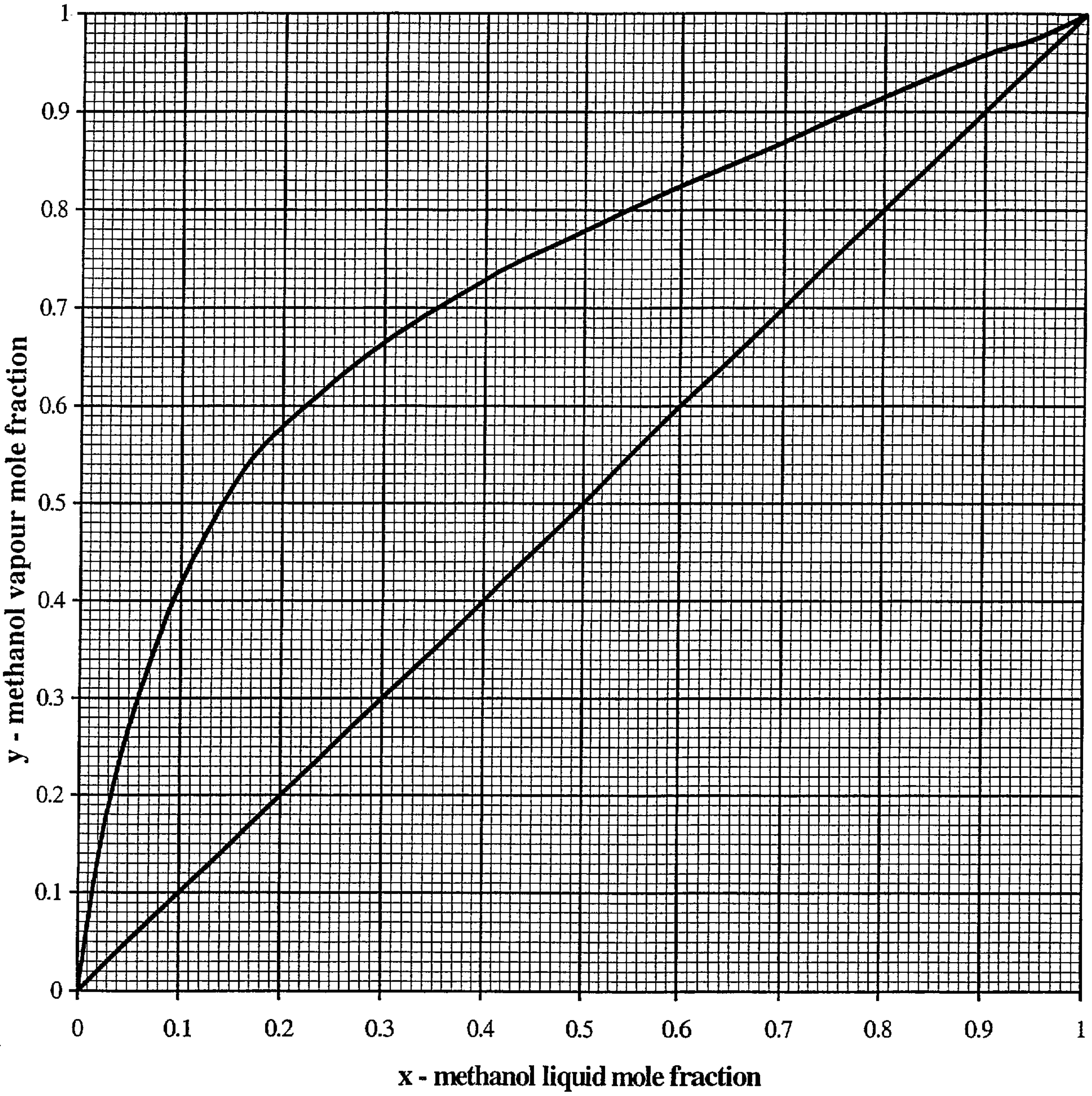

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
y - methanol vapour mole fraction
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
x - methanol liquid mole fraction

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6.

a) Describe the different characteristics, advantages/disadvantages and applications of batch and continuous stirred tank and plug flow reactors. [8]

b) Describe the "plug-flow" assumption as applied to continuous tubular reactors. [7]

c) A continuous stirred tank reactor of volume V is supplied with a reactant A of concentration C_{IN} in a solution with a volumetric flowrate of Q. Derive an expression for the fraction of A converted, X, assuming the contents of the reactor to be completely mixed and the reaction to be first order in A with a rate coefficient of k. [10]

END OF PAPER