UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualification:-

B.Sc.

Biochemical Eng E126: Introduction to Bioprocess Design Principles

COURSE CODE	:	**BENGE126**
UNIT VALUE	:	**0.50**
DATE	:	**16-MAY-03**
TIME	:	**10.00**
TIME ALLOWED	:	**3 Hours**

TURN OVER

Answer ***FOUR QUESTIONS. ONE FROM EACH SECTION PLUS TWO OTHERS.*** **Only the first four answers will be marked.**
ALL questions carry a total of ***25 MARKS*** *each, distributed as shown* [ ]

SECTION A

1. a) Explain the definition and use of Reynolds number for flow in pipes. [10]

b) Using the attached chart estimate the friction factor for the following pipe section.

Flowrate = 100 L/h

Pipe material = Plastic

Pipe diameter = 50mm

Surface roughness = 500 μm

Pipe length = 30 m

Pressure = 3 bar

Fluid = Water [15]

2. a) For flow through a packed bed of particles there is a simple equation relating the flow conditions to the resultant pressure drop. Provide the relationship between flowrate and pressure drop. [5]

b) When specifying a chromatography column your media supplier suggests both doubling the column diameter and halving the particle diameter. If the existing pressure drop is 2 bar what will the new one be? [10]

c) Why might the equations used to answer the above not hold in reality? Your answer should refer to the basic assumptions as well as to the features of real process materials. [10]

3. An antibody fragment produced by *E coli* can be released from the cell by chemical lysis. The product is then recovered by membrane separation. 100 L lysed broth is first concentrated to 50 L which gives 20% yield of the product. It is then proposed to use diafiltration to increase the yield.

(i) How much diafiltration buffer is needed to achieve a final yield of 70%? [10]

(ii) State the assumptions you have made. [5]

(iii) Give an appraisal of this method of antibody fragment recovery considering that the product is to be further purified by high resolution chromatography. [10]

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4. The disk-stack centrifuge is often used in industrial solid-liquid separation due to its continuous mode of operation. You have 100 L fermentation broth which is a mixture of cells, product (a protein) and soluble contaminants. The solids carry over in the centrifuge is 5% and the dewatering level of the sediment is 50% by volume of cells. The level of product recovery is not satisfactory and a washing stage has to be introduced to increase the yield. You can have two options. One is to centrifuge the 100 L broth, and then dilute the sediment using 100 L buffer, and then centrifuge again. The other is to dilute the fermentation broth by adding 100 L buffer, and then centrifuge the diluted broth.

(a) Predict the composition of each stream involved in the two processes. [15]

(b) Summarise the advantages and disadvantages of the two process options. [5]

(c) If the yield in the pilot plant trail is lower that you predicted, discuss the possible reasons. [5]

Background information:

Cell concentration in fermentation broth 40g dry mass/L
Cell wet to dry mass ratio ~ 3
Product concentration in fermentation broth 0.3 g/L
Contaminants are negligible
Assume for the purposes of calculation that the density of the cells and the liquor are the same as 1 kg/L

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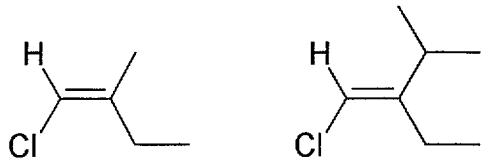
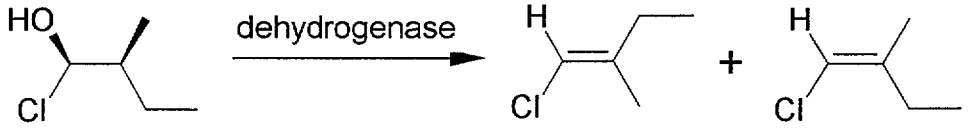
SECTION B

5. a) Compounds A and B can both exist as two geometric isomers. Which isomers of A and B are shown below, E or Z? (Atomic masses: C=12, Cl=35.5, H=1) [5]



A **B**

An identified dehydrogenase enzyme has been found that dehydrates compound **X** to compounds **A** and **C** with the % yields shown below. The reaction goes to completion and is irreversible. The Michaelis constants for the formation of the EC and EA enzyme-substrate complexes are the same ($K_{Ma} = K_{Mc}$), and the turnover constant for the formation of the product A, $k_{catA} = 100\ s^{-1}$.



X **C** 90% **A** 10%

b) G_R is the geometric isomer ratio, analogous to E_R. Calculate G_R. [5]

c) Under the conditions measured, the enzyme reaction rate for both products can be expressed as:

$$v_0 = \left(\frac{k_{cat}}{K_m}\right)[E_o][X]$$

Calculate the turnover constant for the formation of product C, k_{catC}. [10]

d) Separation of the isomers A and C by any method is too expensive to operate at large scale. Briefly describe a strategy that would make the production of compound C cheaper to run at large scale. [5]

PLEASE TURN OVER

6. This question concerns the limited productivity found in enzyme-catalysed reactions.

a) What measures are used to assess productivity in biocatalytic processes and how would you decide which of these are most important? Give typical numerical values for these metrics. [5]

b) What is the cause of low productivities? [5]

c) What techniques are available to increase the product concentration attainable? [5]

d) What techniques are available to increase the reaction rate? [5]

e) Describe in detail with diagrams (as appropriate) the operation of one technique listed in your answers to the previous two parts to this question. [5]

END OF PAPER