National Exams May 2019

04-BS-13, Biology

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is a **CLOSED BOOK EXAM**. One aid sheet allowed written on both sides. Approved Casio or Sharp calculator is permitted.

3. **FIVE (5)** questions constitute a complete exam paper. The first five questions as they appear in the answer book will be marked.

4. Each question is of equal value.

5. Some questions require an answer in essay format. Clarity and organization of the answer are important.

Part I: Solve 3 questions only, 1 from questions 1 and 2, 1 from 3 and 4, and 1 from 5 and 6 out of the following 6 questions (20 marks for each)

Note: For some questions to calculate molecular weights of biomasses, products and substrates, elemental atomic masses will be needed. These are: for C = 12, for H = 1, for N = 14, and for O = 16.

To calculate degree of reduction (γ) of an organic material or biomass, the number of available electrons is needed for various elements. These are 4 for C, 1 for H, -2 for O, and -3 for N.

1. (a) In order to design a bioreactor for a process what type of data (10 important ones) you will need. (10 marks)
   (b) Why you will prefer the following bioreactors, give two reasons for each: Batch, Fed-batch, and Chemostat. (10 marks)

   OR

2. Describe how water move into and out of cells. How water is retained in plant and animal cells? Explain free water, bound water, mechanisms of molecular adsorption and water activity. How these influence material properties? (20 marks)

3. The growth of an organism ($C_{4.4}H_{7.3}N_{0.86}O_{1.2}$) on hexadecane ($C_{16}H_{34}$) can be described by the following stoichiometric equation:

   $C_{16}H_{34} + 12.4\ O_2 + 2.09\ NH_3$ -----> $2.42(C_{4.4}H_{7.3}N_{0.86}O_{1.2}) + \varepsilon\ H_2O + 5.33\ CO_2$

   Calculate (a) the coefficient ε, (b) the respiratory quotient in gmol/gmol and g/g, (c) actual Y_{XS} and maximum Y_{XS} in gmol/gmol and g/g, and (d) heat generated per mole of biomass. Specific growth rate (μ) = 0.5 h^{-1} and maintenance coefficient (m_s) = 0.2 h^{-1}.
   Marks as (a) 4, (b) 3, (c) 9 (d) 4

   OR

4. The growth of yeast (*S. cerevisiae*, X) on glucose (substrate, S) under anaerobic conditions can be described by:

   $C_6H_{12}O_6 + \beta\ NH_3 \rightarrow 0.59\ CH_{1.74}N_{0.2}O_{0.45} + 0.43C_3H_8O_3$ (glycerol) + $1.3C_2H_5OH$ (product, ethanol) + $0.036H_2O + 1.54CO_2$

   Molecular weight of yeast = 25 g/mol, molecular weight of glucose = 180 g/mol, molecular weight of ethanol = 46 g/mol, and molecular weight of

ammonia = 17 g/mol; maximum specific growth rate, μ_{max} = 0.4 h^{-1}, maintenance coefficient, m_s = 0.2 h^{-1} and specific rate of product formation due to maintenance, m_p = 0.1 h^{-1}.

(a) Determine the biomass yield coefficient Y_{XS} (g/g) and Y'_{XS} (g/g). (8 marks)
(b) Determine the product yield coefficients Y_{PS} (g/g) and Y'_{PS} (g/g). (8 marks)
(c) Determine the coefficient β. (4 marks)

5. Consider the aerobic growth of *S. cerevisiae* on glucose, described by

$$CH_2O + aO_2 + bNH_3 \rightarrow cCH_{1.8}N_{0.2}O_{0.5} + dH_2O + eCO_2$$

Show that the yield coefficient for biomass (Y_{XS} in gmol/gmol) can be related to the degree of reduction of glucose, γ_S, and the respiratory quotient, RQ, by the following equation using electron balance:

$$Y_{XS} = \frac{1 - 0.25\gamma_S.RQ}{1 - 1.05RQ}$$

(20marks)

OR

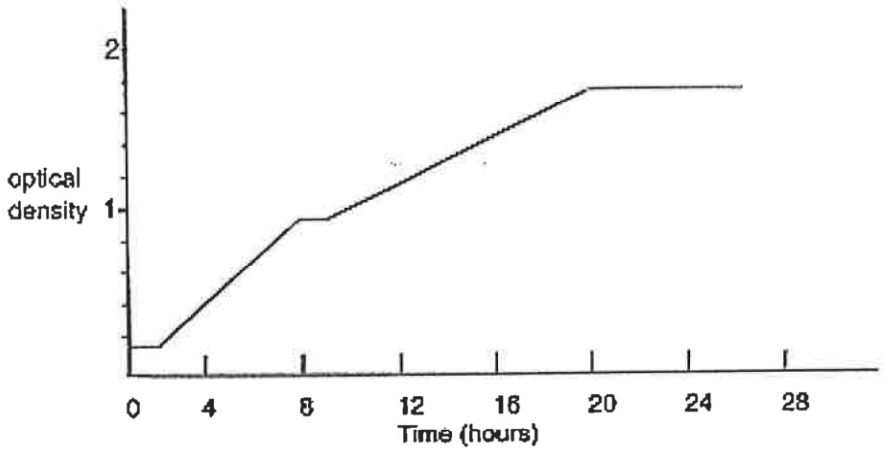
6. *Azotobacter vinelandii* is investigated for the production of alginate from sucrose. In a continuous fermenter at 28°C with ammonia as nitrogen source, the yield of alginate was found to be 4 g/g oxygen consumed. It is planned to produce alginate at a rate of 5 kg/h. Since the viscosity of alginate in aqueous solution is considerable, energy input due to mixing the broth can not be neglected. The fermenter is equipped with a flat-bladed disc turbine; at a satisfactory mixing speed and air flow-rate, power requirements are estimated at 1.5 kW. Estimate the cooling requirements. (20 marks)

Part II. Answer any 2 questions only out of the following 3 questions (20 marks for each question)

7. (a) What are the three basic shapes of bacteria? How are prokaryotic and eukaryotic cells alike? How are they differ? (12 marks)
(b) Describe the shapes of viruses. List the main characteristics of viruses. (8 marks)

8. (a) What characteristics distinguish fungi from other microorganisms? In what ways are fungi beneficial, and in what ways are they harmful in food? (10 marks)
   (b) What are the similarities and differences between animal, plant and bacterial viruses? (10 marks)

9. Below is a growth curve for an *E. coli* culture growing on a glucose : lactose based medium. By referring to the curve below answer the following questions



(a) The transcription of the beta-galactosidase and lactose permease genes begins at? (6 marks)
(b) During what period of time do the bacteria utilize lactose as their sole source of carbon and energy? (7 marks)
(c) During what period of time do the bacteria utilize glucose as a carbon-energy source? (7 marks)