National Exams December 2016

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 CLOSE BOOK EXAM. One aid sheet allowed written on both sides. Approved 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 any 3 questions out of the following 5 questions (20 marks for each)

Note: For some questions in order 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.

1. (a) The wall of a plant cell is a rigid structure that restricts swelling and relative movement. If it were not for rigid casing of the cell wall, plant cells would continue to absorb water by osmosis, until they burst. What is the composition of plant cell walls? (5 marks)

(b) What is the definition of pigment? Why the plant leaves appear green? (5 marks)

(c) How you will relate turgor pressure with plant tissue rigidity? (5 marks)

(d) Describe with diagram the typical structure of wheat grain or corn kernel. (5 marks)

2. A well-mixed fermenter of volume V contains cells initially at concentration x_o. A sterile feed enters the fermenter with volumetric flow rate F; fermentation broth leaves at the same rate. The concentration of substrate in the feed is s_i. The equation for rate of cell growth is: $r_x = k_1 x$; and the expression for rate of substrate consumption is: $r_s = k_2 x$; where k_1 and k_2 are rate constants with dimensions 1/h; r_x and r_s are dimensions of kg/(l.h), and x is the concentration of cells in the fermenter. (a) Derive a differential equation for the unsteady state mass balance of cells. (10 marks) (b) From this equation, what must be the relationship between F, k_1 and the volume of liquid in the fermenter at steady state? (4 marks) (c) Solve the differential equation to obtain an expression for cell concentration in the fermenter as a function of time. (6 marks).

3. Production of single cell protein from hexadecane is described by the following stoichiometric equation:

$$C_{16}H_{34} + a\ O_2 + b\ NH_3 \text{ -----> } c(CH_{1.66}N_{0.2}O_{0.27}) + d\ CO_2 + e\ H_2O$$

Where $CH_{1.66}N_{0.2}O_{0.27}$ represents the biomass. If respiratory quotient (RQ) is 0.43, determine the stoichiometric coefficients for the above biological equation (20 marks).

4. The biological equation for respiration of glucose is:

$$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$$

Candida utilis cells convert glucose to CO_2 and H_2O during growth. The cell (biomass) composition is $CH_{1.84}O_{0.55}N_{0.2}$, and 5% ash) . Yield of biomass from substrate is 0.5 g/g. Ammonia is used as nitrogen source.

(a) What is the oxygen demand with growth compared to that without? (10 marks) (b) *C utilis* is also able to grow with ethanol (MW = 46) as substrate, producing cells of the same composition as above. On a mass basis, how does the maximum possible biomass yield from ethanol compare with the maximum possible yield from glucose? (10 marks)

Glucose degree of reduction (γ_S) = 4.0; ethanol degree of reduction (γ_S) = 6.0; biomass degree of reduction (γ_B) = 4.14. for glucose w (carbon atom) = 6; for ethanol w = 2.

5. Citric acid is manufactured using submerged culture of *Aspergillus niger* in a batch reactor operated at 30 °C. Over a period of two days, 2500 kg glucose and 860 kg oxygen are consumed to produce 1500 kg citric acid, 500 kg biomass and other products. Ammonia is used as nitrogen source. Power input to the system by mechanical agitation of the broth is about 15 kW (8.64×10^6 kJ); approximately 100 kg water is evaporated over the culture period. Estimate the cooling requirements.

The heat of reaction is -460 kJ/mol of oxygen. The enthalpy of evaporation is 2430.7 kJ/kg of water vapour. The biological equation can be written as:

$$C_6H_{12}O_6 + O_2 + NH_3 \rightarrow \text{Biomass} + CO_2 + H_2O + \text{citric acid}$$

(20 marks)

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

6. (a) Briefly compare prokaryotes with eucaryotes in terms of internal structure and functions. (5 marks)

(b) What are the major classes of fungi? Briefly cite the differences among these classes. (5 marks)

(c) Briefly compare protozoa with algae in terms of their cellular structures and functions. (5 marks)

(d) What are differences in cell envelope structure between Gram –ve and Gram +ve bacteria (5 marks)

7. A strain of mold was grown in a batch culture on glucose and the following data were obtained.

Time, h	Cell concentration, g/l	Glucose concentration, g/l
0	1.25	100
9	2.45	97
16	5.1	90.4
23	10.5	76.9
30	22	48.1
34	33	20.6
36	37.5	9.38
40	41	0.63

(a) Calculate the maximum net specific growth rate. (10 marks) (b) Calculate the apparent growth yield. (5 marks) (c) What maximum cell concentration could one expect if 150 g of glucose were used with the same size inoculum? (5 marks)

Use the regular graph paper provided for data plotting after converting cell concentration into log values or use semilog paper provided without converting to log values.

8. Define the following terms and when there is more than one, compare and contrast their general characteristics with those of others in the same group.

(a) Cytoplasm (3 marks)

(b) Nucleus, nuclear zone (5 marks)

(c) Ribosome, chloroplast, mitochondria (6 marks)

(d) Spirilla, cocci, bacilli (6 marks)