KATHMANDU UNIVERSITY
End Semester Examination
March/April, 2017

Marks Scored:

Level : B.Tech.
Year : II

Course : BIOT 204
Semester : I

Exam Roll No. :

Time : 30 mins.

F. M. : 20

Registration No. :

Date : MAR 3 0 2017

SECTION "A"

[10 Q. × 1 = 10 marks]

Tick the best answer(s).

1. In a steady-state system, which of the following conditions is likely for in ≠out
[ ]Total number of moles without reaction [ ] Total mass with reaction
[ ]Total number of moles with reaction [ ] Total mass without reaction

2. Which of the following strategies is best for removing off-gas or unnecessary by-products from the product stream during a continuous fermentation process?
[ ] Purge stream [ ] Recycle stream [ ] By-pass stream [ ] Closed-loop stream

3. In the following overall reaction for microbial conversion of glucose to L-glutamic acid:

$$\underset{\text{(glucose)}}{C_6H_{12}O_6} + NH_3 + 3/2\ O_2 \rightarrow \underset{\text{(glutamic acid)}}{C_5H_9NO_4} + CO_2 + 3H_2O$$

The mass of oxygen required to produce 15 g glutamic acid is
[ ] 5.2 g. [ ] 10.3 g [ ] 4.9 g. [ ] 6.5 g.

4. What is the enthalpy of 150 g formic acid at 70 °C and 1 atm. relative to 25 °C and 1 atm.? Specific heat capacity for formic acid in the temperature range of 20 – 100 °C is 0.524 cal./°C/g.
[ ] 4542.2 cal. [ ] 3294.0 cal. [ ] 3537.0 cal. [ ] 3640.1 cal.

5. Amyloglucosidase from *Endomycopsisbispora* is immobilised in polyacrylamide gel. Activities of the enzyme were determined at 80 °C and deactivation rate constant of the enzyme is found to be 0.03 min^{-1}. What is the half-life for of the enzyme?
[ ] 21.1 min. [ ] 14.5 min [ ] 20.2 min. [ ] 23.1 min.

6. In Michaelis–Menten equation, $r = \frac{\mu_{max}\, S}{S+K_m}$, When S>>> K_m, the reaction rate becomes:
[ ] Zero order [ ] First order [ ] Second order [ ] Third order

7. During the phases of batch culture, which of the following phase/s has $\mu < \mu_{max}$?
[ ] Lag [ ] Acceleration [ ] Decline [ ] Stationary

8. Which of the following are strictly non-Newtonian, but once the flow starts they behave essentially as Newtonian fluids (i.e. shear stress vs shear rate is linear)?
[ ] Bingham plastic [ ] Pseudoplastic
[ ] Dilatant [ ] Bingham pseudoplastic

9. In Casson plastics, with an increasing shear rate when the yield stress is exceeded, the apparent viscosity
[ ] Increases [ ] Remains constant [ ] Decreases [ ] Sharply increases

10. Which of the following impellers is/are recommended for mixing for high viscous liquids (with viscosity > 10^5 centipoise)?
[ ] Propellers [ ] Anchors [ ] Helical screws [ ] Helical ribbon

SECTION "B"

[10 Q. × 1 = 10 marks]

Fill in the blanks.

11. General mass balance equation for steady state systems is _____ _____.

12. Unsteady-state energy-balance equation for a system with only one inlet and one outlet stream with zero work done is _____ _____.

13. In the synthesis of single cell protein (SCP) from using organic substrates with the following expression: $C_wH_xO_yN_z + aO_2 + bH_gO_hN_i \rightarrow cCH\alpha O\beta N\delta + dCO_2 + eH_2O$; _____ and_____ represents the substrate and SCP, respectively.

14. In question number 13 above (Section B), the number of electrons in the substrate can be expressed by _____.

15. The heat required to raise the temperature of 1 g of pure water by 1 °C at 1 atm. pressure expressed in terms of _____.

16. Unit for second order rate constant is _____.

17. Cell death during sterilization can be described or modelle by _____ order process.

18. If consumption of chemical species "G" is described by the first order reaction model, then its rate of consumption of "G" can be written as _____.

19. In a plot of shear stress versus shear rate, if the relationship is such that stress increases linearly with shear rates, where the slope can be given by the _____of the fluid.

20. During the mixing of ungassed newtonian fluids, in the turbulent regime, a 10% increase in impeller diameter increases the power required by more than _____; a 10% increase in stirrer speed raises the power required by over _____ .

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Time : 2 hrs. 30 mins.

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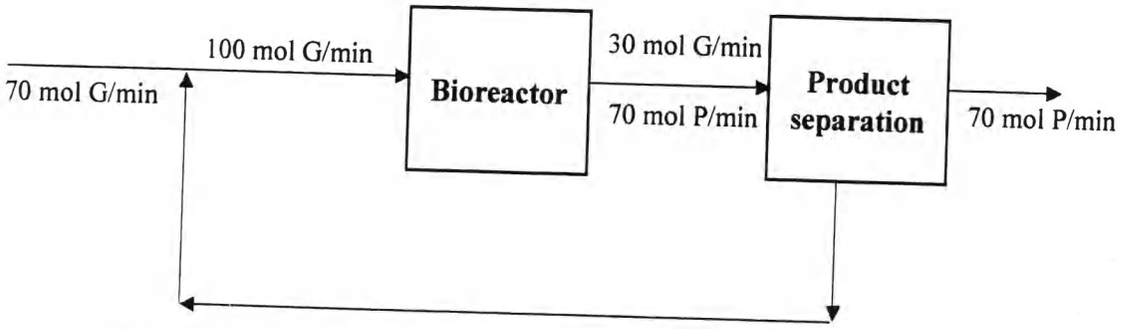
F. M. : 55

SECTION "C"
[5Q × 5 = 25 marks]

Solve *ANY FIVE* questions.

1. From the figure below, answer the following questions.
   a. Find the overall and single pass conversion of Glucose? [2]
   b. What is the recycled amount of G? Why recycling is needed? [1+1 = 2]
   c. What are the possible reasons for such low conversion of G? [1]



2. The following reaction catalyzed by phosphoglucomutase occurs during breakdown of glycogen:

   glucose 1-phosphate ↔ glucose 6-phosphate

   A reaction is started by adding phosphoglucomutase to 0.04 gmol glucose 1-hosphate in 1-liter solution at 25 °C. The reaction proceeds to equilibrium at which the concentration of glucose 1-phosphate is 0.002 M and the concentration of glucose 6-phosphate is 0.038 M.
   a. Calculate the equilibrium constant. [2]
   b. What is the theoretical yield? [1]
   c. What is the yield based on amount of reactant supplied? [1]
   d. Comment on the differences in two different yields. [1]

3. List and explain briefly any five factors that can effect the rheology of fermentation broths. [5]

4. a. For efficient mixing with a single impeller, the depth of liquid in the tank should be no more than 1.0 - 1.25 times the tank diameter. If the diameter of the bioreactor is 1m and height 2 m. What will be an appropriate working volume for the reactor? [2]
   b. How this working volume will change if baffles are provided? [1]
   c. Explain briefly the mechanism of mixing with the description of different physical processes involved with an example. [3]

5. a. A fermentation broth with viscosity 10^{-2} Pa s and density 1000 kg m^{-3} is agitated in two 2.7 m^3 baffled tanks using a Rushton turbine with diameters 0.5 m and 0.6 m, respectively, and stirrer speed 1 s^{-1}. Calculate and comment on the mixing times. [2]
   b. Discussion briefly the relation between Reynolds number, power number and power requirement for mixing when dealing with un-gassed Newtonian fluid. [3]

6. Describe different types of viscometers with some examples of their biotechnological applications. [5]

SECTION "D"
[3Q × 10 = 30 marks]

Attempt *ANY THREE* questions.

7. Production of single-cell protein from glucose is described by the following reaction equations:

Glucose: $C_6H_{12}O_6 + a\ O_2 + b\ NH_3 \rightarrow c\ C_{4.4}H_{7.3}N_{0.86}O_{1.2} + d\ H_2O + e\ CO_2$ (i)

Hexadecane: $C_{16}H_{34} + a\ O_2 + b\ NH_3 \rightarrow c(C_{4.4}H_{7.3}N_{0.86}O_{1.2}) + d\ H_2O + e\ CO_2$ (ii)

where $C_{4.4}O_{7.3}N_{0.86}O_{1.2}$ represents the biomass. Assume that experimental measurements for a certain organism have shown that cells can convert two-thirds (wt/wt) of the substrate carbon (alkane or glucose) to biomass.

a) Determine the stoichiometric coefficients for both of the reactions (i) and (ii). [5]

b) Calculate the yield coefficients $Y_{X/S}$ (g dwcell/g substrate), $Y_{X/O2}$ (g dwcell/g O_2) for both of the reactions. Comment on the differences. [5]

8. *Acetobacteraceti* bacteria convert ethanol to acetic acid under aerobic conditions. A continuous fermentation process for vinegar production is proposed using non-viable *A. aceti* cells immobilised on the surface of gelatin beads. The production target is 2 kg/h acetic acid; however, the maximum acetic acid concentration tolerated by the cells is 12%. Air is pumped into the fermenter at a rate of 200 gmol/h.

$$C_2H_5OH + O_2 \rightarrow CH_3COOH + H_2O$$
(ethanol) (acetic acid)

a) What minimum amount of ethanol is required? [3]

b) What minimum amount of water must be used to dilute the ethanol to avoid acid inhibition? [3]

c) What is the composition of the fermenter off-gas? [4]

Draw a flow diagram and mention the necessary assumptions.

9. An electric heating-coil is immersed in a stirred tank. Solvent at 15 °C with heat capacity 2.1 kJ/kg/°C is fed into the tank at a rate of 20 kg/h. Heated solvent is discharged at the same flow rate. The tank is filled initially with 200 kg cold solvent at 10°C, the rate of heating by the electric coil is 800 W. Calculate the time required for the temperature of the solvent to reach 80°C. Draw a flow diagram and mention the necessary assumptions. [10]

10. *Escherichia coli* is being used for production of recombinant porcine growth hormone. The bacteria are grown aerobically in batch culture with glucose as growth-limiting substrate. Cell and substrate concentrations are measured as a function of culture time; the results are listed below:

Time (h)	Cell concentration, X (kgdw cell/m^3)	Substrate concentration, S (kg/m^3)
0.0	0.20	25.0
0.33	0.21	24.8
0.5	0.22	24.8
0.75	0.32	24.6
1.0	0.47	24.3
1.5	1.00	23.3
2.0	2.10	20.7
2.5	4.42	15.7
2.8	6.90	10.2
3.0	9.40	5.2
3.1	10.90	1.65
3.2	11.60	0.2
3.5	11.70	0.0
3.7	11.60	0.0

a) Make a graph, plotting dry cell weight per volume (X) and glucose concentration (S) as a function of time. [2]

b) Comment on the X vs. Time curve with respect to the expected phases of batch growth, i.e. what phases do you see?, what is their duration? [4]

c) How can you use this data to calculate the kinetic parameters of *E. coli* growth and substrate consumption? Mention the models that can be used and methods only. [4]