University of Ruhuna- Faculty of Technology

Bachelor of Biosystems Technology Honours Degree
Level 2 (Semester I) Examination, June/July 2026
Academic year 2024/2025

Course Unit: BST2143-Bio Process Technology I (Written)

Duration: 2 hours

INSTRUCTIONS:

- Answer any **Four (04)** out of the four questions provided.
- Use a separate answer booklet for your answers.
- Each question must begin on a new page.
- If more than four questions are answered, only the **first four** will be marked.

1. Microorganisms are widely used in industrial bioprocesses to produce different commercial products. The success of such a process depends on understanding the general bioprocess steps, the nature of the product, the producing organism, and the suitability of the selected strain for large-scale production.

   a. Briefly describe the basic steps of a bioprocess by using example product as yoghurt. **(20 marks)**

   b. Explain how the production of a microbial secondary metabolite is induced during an industrial fermentation process using an antibiotic as an example. **(40 marks)**

   c. A bioprocess company isolated three microorganisms from soil and tested them for antibiotic production. The results are given below.

Isolate	Inhibition zone (mm)	MIC (µg/mL)	Product titer(g/L)	Aeration requirement	Process issue	Stability
A	12	64	0.8	Low	Low foam	Production lost after 3 batches
B	24	8	2.2	High	Foam formation	Stable for 10 batches
C	18	16	1.5	Moderate	Possible toxic by-product	Stable for 5 batches

As a bioprocess technologist, evaluate the above isolates and select the most suitable microorganism for industrial antibiotic production. **(40 marks)**

2. In industrial bioprocessing, successful production depends on the preparation of an active inoculum and the control of enzymatic reactions. Enzyme kinetics is used to understand how reaction rate changes with substrate concentration and how inhibitors affect enzyme activity.

a. List the steps involved in seed train and inoculum development and state the purpose of each step. **(20 marks)**

b. Briefly describe the difference between competitive and non-competitive inhibition using Michaelis Menton graph. **(30 marks)**

c. A student carried out an enzyme assay using different substrate concentrations and recorded the following initial reaction rates.

$$\frac{1}{v} = \frac{Km}{Vmax} \cdot \frac{1}{[S]} + \frac{1}{Vmax}$$

Substrate concentration, S (mM)	Initial rate, v (µmol/min)
0.5	5.0
1.0	8.3
2.0	12.5
4.0	16.7
8.0	19.0

Draw a Lineweaver–Burk plot and, determine the Vmax and Km of the enzyme-catalysed reaction. **(50 marks)**

3. The fermentation process is scaled up from laboratory to pilot and industrial scales, careful consideration must be given to impeller selection, power draw, vessel geometry, and scale-up criteria to ensure consistent performance.

a. List three common scale-up criteria and state for which type of process each is most suitable.

(15 Marks)

b. A bioprocess facility needs to produce 50,000 L of broth per day. Each batch cycle (including fill, sterilisation, fermentation, harvest, cleaning) takes 12 hours. The fermenter has a typical fill ratio (working volume / total volume) of 0.75.

i. Calculate the required working volume per batch (in m^3) to meet the daily production target.

(15 Marks)

ii. If the vessel height-to-diameter ratio (Ht/Dt) is 2.5, determine the vessel diameter and total height (in metres) **(25 Marks)**

c. A stirred-tank bioreactor with working volume 5 m^3 is used for a bacterial fermentation. The impeller is a Rushton turbine (power number Np=5.0) with diameter Di=0.6. The broth density ρ=1020 kg/m^3. The impeller rotational speed is N=4 rev/s.

i. Calculate the ungassed power draw P_0 in kW. **(15 Marks)**

ii. If the same impeller is used at a larger scale with Di=1.2 m and the same tip speed ($vt=\pi DiN$), calculate the new rotational speed and the new ungassed power? **(30 Marks)**

4. In aerobic microorganism cultivation processes, it is necessary to supply nutrients and oxygen to the microorganism cells. The oxygen transfer rate (OTR) is critical for maintaining cell growth and enzyme production.

a. Briefly explain five (5) factors affecting for oxygen transfer. **(30 Marks)**

b. A fermentation broth contains *Saccharomyces cerevisiae* at a concentration of 12 g/L. The specific oxygen uptake rate of the culture is 272 mg $O_2 \cdot g^{-1} \cdot h^{-1}$.

i. Calculate microbial oxygen demand in mg $O_2 \cdot L^{-1} \cdot h^{-1}$. **(15 Marks)**

ii. At steady state, if the dissolved oxygen concentration (C_L) is 2.25 mg/L and the saturation concentration (C^*) is 7.5 mg/L, calculate the volumetric oxygen mass transfer coefficient (k_La) in h^{-1}. **(15 Marks)**

c. A *Saccharomyces cerevisiae* fermentation is scaled up from a 100-litre laboratory bioreactor to a 10,000-litre industrial fermenter. At the laboratory scale, the volumetric oxygen mass transfer coefficient (k_La) is 180 h^{-1} and the maximum biomass concentration is 12 g/L. At the industrial scale, using the same specific power input and aeration rate (1 vvm), the measured k_La drops to 65 h^{-1}, and the dissolved oxygen concentration falls to 0% when biomass reaches only 5 g/L.

i. Briefly describe **four (4)** factors that cause a reduction in k_La when scaling up from 100 L to 10,000 L. **(20 Marks)**

ii. Briefly explain **two (2)** practical engineering modifications that could increase k_La to at least 150 h^{-1} in the 10,000 L fermenter. **(20 Marks)**

5. Modern bio-manufacturing facilities are adopting innovative technologies to improve efficiency, reduce costs, and meet regulatory requirements.

a. Briefly explain **four (4)** advantages of single-use technology (SUT) over stainless steel systems. **(30 Marks)**

b. Compare traditional batch processing with continuous biomanufacturing. **(30 Marks)**

c. Discuss how digitalisation and AI are transforming biomanufacturing industry. **(40 Marks)**

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