Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	FERMENTATION ENGINEERING TECHNOLOGY
COURSE CODE	:	BNN 30304
PROGRAMME CODE	:	BNN
EXAMINATION DATE	:	JUNE/JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) As illustrated in **Figure Q1(a),** identify the types of bioreactors and differentiate their configuration, oxygen requirement and applications.

(6 marks)

(b) The oxygen demand of fermentation process is normally satisfied by aerating and agitating the fermentation broth. Based on bioreactors identification in **Q1(a),** explain on how a complete aeration and mixing could be achieved by:

(i) The internal loop and the external loop of *Bioreactor A*.
(Please be noted that the rising tube and the down coming tubes are the features of *Bioreactor A*)

(4 marks)

(ii) The components (sparger and impeller) involved in aeration and agitation of *Bioreactor B*.

(4 marks)

(c) Baffle is one of the structural components involved in aeration and agitation. Sketch the suitable position of baffles in bioreactor for *low viscosity liquids* and *viscous cells suspension* during fermentation.

(3 marks)

(d) List **TWO (2)** important properties of antifoam and interpret on how it works during fermentation.

(3 marks)

Q2 (a) Oxygen Transfer Rate (OTR) and Oxygen Uptake Rate (OUR) determination is essential in order to establish aeration efficiency during fermentation. Given that a 10,000 L stirred tank bioreactor containing a 5 g / L of growing *Bacillus thuringiensis* cells, with a specific rate of oxygen consumption, qO_2 = 20 mmoles O_2 / (g cells hr). The kLa value was recorded as 169 mmol O_2/ 1 hr. (P^* = 0.0263 atm and PO_2 = 0.21 atm).

(i) Calculate OUR and OTR of the fermentation system.

(5 marks)

(ii) Based on **Q2(a)(i),** predict the modification could be made on the bioreactor operation

(3 marks)

(b) A fermentation broth with viscosity 10^{-2} Pa.s and density 1000 kg/m^3 is agitated in a 50 m^3 baffled tank using a marine propeller 1.3 m in diameter. Calculate the power required for a stirrer speed of 4 s^{-1}. (N_p = 0.35)

(4 marks)

(c) Most scale up/down involve the exploitation of a biological opportunity.

(i) Interpret the concept and importance of scale up or scale down in a fermentation industry.

(3 marks)

(ii) After a batch fermentation, the system is dismantled and approximately 75% of the cell mass is suspended in the liquid phase (2 L), while 25% is attached to the reactor walls and internals in a thick film (ca. 0.3 cm). Work with radioactive tracers shows that 50% of the target product (intracellular) is associated with each cell fraction. The productivity of this reactor is 2 g product/l at the 2 L scale. Calculate the productivity at 20,000 L scale if both reactors had a height-to-diameter ratio of 2 to 1.

(5 marks)

Q3 One of the functions of an enzyme is as a catalyst to catalyse biological reactions in the body. At present, the enzymes are also used to catalyse industrial reactions outside the body. These enzymes are often bound to a support or immobilised and can be used for a wide range of purposes.

(a) Name **THREE (3)** commonly employed support materials for immobilisation of an enzyme.

(3 marks)

(b) Identify **TWO (2)** important properties of support material to be an ideal support in immobilized-enzyme technology.

(2 marks)

(c) The techniques for enzyme immobilization is one of the critical factors that can affect the performance of immobilized enzyme. Illustrate **FIVE (5)** most commonly used techniques for immobilization of enzymes on solid support.

(5 marks)

(d) Examine **THREE (3)** advantages of using immobilized enzymes over soluble enzymes in industry.

(6 marks)

(e) In the past decades, nanotechnology has been applied in various industries and fields, particularly in pharmaceutical, biosensor, bioremediation, agriculture and food processing industries. Rapid growth of nanotechnology has also opened a new frontier in the development of nanostructure materials as supports for immobilized enzymes. Evaluate the use of nanotechnology in enzyme immobilization.

(4 marks)

Q4 Industrial fermentation is the intentional use of fermentation by microorganisms such as bacteria and fungi as well as eukaryotic cells like chinese hamster ovary (CHO) cells and insect cells, to make products useful to humans.

(a) List **THREE (3)** microorganisms (genus and species) used in fermentation and explain its application in industry.

(6 marks)

(b) Outline the flow of **ONE (1)** fermentation process which uses one of the microorganisms mentioned in **Q4(a)**.

(4 marks)

(c) Discuss **TWO (2)** limitations related to the fermentation process in **Q(4)(b)** and suggest improvements that could be made on the process.

(4 marks)

(d) In your opinion, why would the cost of production and recovery of fermented product be high? Extensively explain.

(6 marks)

Q5 (a) *Rhizopus* is a fast-growing fungi and actively producing lipases and proteases in the first stages of soybean fermentation. The species are also among the prevalent opportunists causing infections in severely compromised patients. In addition, *Rhizopus* may harbor endosymbiotic proteobacteria, which produce some highly toxic secondary metabolites. Debate on the health risks of the application of *Rhizopus* in food production.

(4 marks)

(b) Industrial processes often use recombinant microorganisms and animal cells, leading to some health issues relating to the use of the genetically modified organisms (GMOs). As a biotechnologist who is working in a bioprocess plant, examine **TWO (2)** potential risks of using GMOs and recommend solutions to reduce the risks.

(4 marks)

(c) Mycotoxins are natural compounds with a low molecular weight produced by filamentous fungi as secondary metabolites. They are generated during malting and brewing process in the production of beer. When exposed to optimal mycotoxin synthesis conditions, they create a toxic environment being able to cause diseases in animals and human beings. Provide **TWO (2)** mitigation strategies and fully explain the containment approach in minimizing exposure to the hazardous substances.

(4 marks)

(d) Predict and thoroughly discuss the future of fermentation engineering technology.

(8 marks)

-END OF QUESTIONS -

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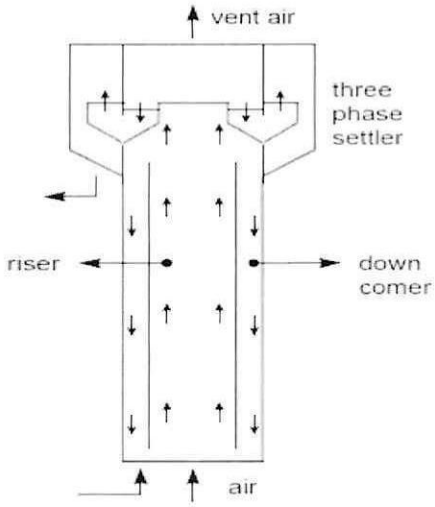
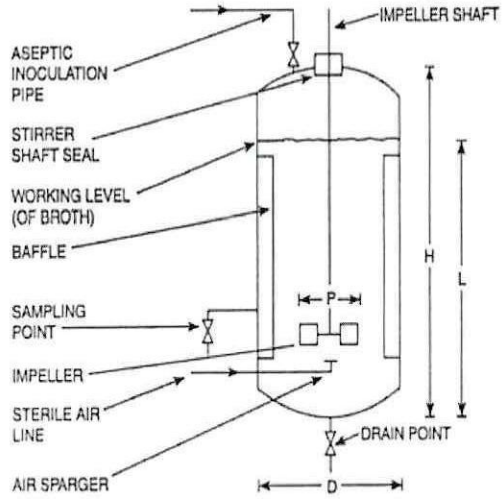


Bioreactor A



Bioreactor B

Figure Q1(a)

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FORMULA:

1. $V = \pi r^2 H$
2. $Re = \frac{ND^2\rho}{\mu}$
3. $N = \frac{P}{\rho N^3 D^5}$
4. $P = k_1 \mu N^2 D^3$
5. $P = N_P \rho N^3 D^5$
6. $k_L a\ (C^* - C_L)$
7. $q_{o2}X$
8. $V = \frac{1}{4}\pi D^2 H = \frac{1}{4}\pi D^2 .2D = \frac{1}{2}\pi D^3$
9. $S = \pi D.H = \pi D.2D = 2\pi D^2$