**National Exams Dec 2014**

**04-Chem-B4, Biochemical Engineering**

**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. Any non-communicating calculator is permitted.**

3. **FIVE (5) questions constitute a complete exam paper. ANSWER ALL FIVE QUESTIONS.**

4. **Each question is of equal value.**

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

**Question 1 (20 marks)**

A small wastewater plant is operated at 5 deg C at an industrial site. Microorganisms are being applied in a well mixed stirred tank system of working volume ($V_L$) 10 $m^3$ to treat the wastewater. A single Rushton turbine impeller is applied for mixing. The impeller diameter is 0.936 m and the rotational speed is 1 RPS. Assume the density and viscosity of the broth are 1000 kg/m3 and $10^{-3}$ Pa.s respectively. Assume the power number $N_p$ = 6 and the ratio of gassed power to total power supplied is 0.6.

(a) What is the maximum volumetric flux of oxygen (in **g $O_2$ per $m^3$ per h**) which can be supplied to the water?

(b) If the plant is now operated at 15 deg C, in your opinion could the oxygen supply become limiting and why or why not? Only provide a QUALITATIVE explanation for part (b).

**Given the following information:**

The solubility of oxygen in water is given by the following equation

**DO (ppm)** = $\frac{(P-p)\times 0.678}{35+t}$ **0 ºC < t < 30 ºC and P, p = total and partial pressure (oxygen) in Torr, DO stands for dissolved oxygen and t is temperature in deg C.**

Assume that the the mole fraction of oxygen in air is 0.21 and the total pressure is 1 atmosphere (760 Torr).

$$k_L a = 9.09 \times 10^{-4} \left(\frac{P_g}{V_L}\right)^{0.7}$$

**Here $P_g/V_L$ is in kW/$m^3$ and $k_La$ is in $s^{-1}$**

**Also given:**

**Power number = $N_P = Pg_c/n^3D_i^5\rho$ where P is in Watts (for SI units)**

**Reynolds number = $N_{Re} = nD_i^2\rho/\mu$**

Where all symbols have their usual meaning

**Question 2 (20 marks)**

a) An immobilized packed bed column is 20 cm in diameter and 2 m in height. It is packed with 18 kg of immobilized glucose isomerase enzyme particles. The particle diameter is 2 mm and the particle density is 1500 Kg/ $m^3$,.Calculate the total surface area of the all particles per unit of bed volume ($\alpha$) (reported as $cm^{-1}$). **(10 marks)**

b) If the observed rate of reaction for immobilized spherical catalyst particles of diameter 1 mm is 200 micromol/($cm^3$ of catalyst).min, and the initial substrate concentration $S_0$ is 100 mol/$m^3$ and the observable Thiele modulus is 4.3, what is the effective diffusivity of the substrate (in $m^2/s$) in the immobilized enzyme particle. **(10 marks)**

**Question 3 (20 marks)**

(i) Compare and contrast oxygenic and and anoxygenic photosynthesis (10 marks).

(ii) Discuss and describe in detail **any one** of the following (1) Prokaryotic Cell; (2) Components of Eukaryotes (3) Fermentation metabolism. (10 marks)

**Question 4 (20 marks)**

(i) Prove that for a chemostat (steady state continuous bioreactor) system with recycle can be operated with the dilution rate is exceeding the specific cell growth rate of cells until washout (10 marks).

(ii) Compare and contrast biomass productivity in batch and continuous cultivation in bioreactors when the inlet or initial substrate concentration $S_0 >> K_s$ where $K_s$ is the substrate limitation constant. (10 marks).

**Question 5 (20 marks)**

(i) What is meant by TCA or citric acid cycle. Discuss in detail aerobic respiration in cells.

**(ii)** Explain briefly the principles of fat metabolism in living cells.