# Department of Biochemical Engineering & Biotechnology

**Bioprocess Calculations (BEL 102)**

**Major Test**

**Max. Marks: 40**
**Time: 2 h (10:30 h - 12:30 h)**
**Date: April 29, 2008**
**Venue: VI 301**

**Answer all Questions**

1. The steady state substrate and biomass concentrations for a continuous bioreactor operated at various dilution rates are given below. Given that the fresh feed concentration is 700 mg/L, calculate the values of maximum specific growth rate, saturation constant, yield coefficient and maintenance coefficient of the cell.

| Dilution rate ($h^{-1}$) | Substrate concentration (mg/L) | Biomass concentration (mg/L) |
|---|---|---|
| 0.30 | 45 | 326 |
| 0.25 | 41 | 328 |
| 0.20 | 16 | 340 |
| 0.12 | 8.0 | 342 |
| 0.08 | 3.8 | 344 |

[6]

2. Steam (that is used to heat a biomass) enters the steam chest, which is segregated from the biomass, in a bioreactor, at 250$^{O}$C saturated, and is completely condensed in the steam chest. The rate of the heat loss from the steam chest to the surroundings is 1.5 kJ/s. The reactants are placed in the vessel at 20$^{O}$C and at the end of the heating the material is at 100$^{O}$C. If the charge consists of 150 kg material with an average heat capacity of 3.26 J/g K, how many kg of steam are needed per kg of charge? The charge remains in the reaction vessel for 1 h.

[6]

3. An electric heating-coil is immersed in a bioreactor. Solvent at 15$^{O}$C with heat capacity 2.1 kJ/kg $^{O}$C is fed into the bioreactor at a rate of 15 kg/h. Heated solvent is discharged at the same flow rate. The bioreactor is filled initially with 125 kg cold solvent at 10$^{O}$C. The rate of heating by the electric coil is 800W. Calculate the time required for the temperature of the solvent to reach 60$^{O}$C.

[6]

4. An iron bar 2 cm x 3 cm x 10 cm at a temperature of 95$^{O}$C is dropped into a barrel of water at 25$^{O}$C. The barrel is large enough so that the water temperature rises negligibly as the bar cools. The rate at which heat is

transferred from the bar to the water is given by the expression Q (J/min) = 0.050 A ($T_b - T_w$) where A ($cm^2$) is the exposed surface area of the bar. $T_b$, $T_w$ are, respectively, the surface temperature of the bar and the temperature of the water. The heat capacity of the bar is 0.460 J/g $^0$C. Heat conduction in iron is rapid enough for the temperature $T_b$ to be considered uniform throughout the bar. Determine the final steady state temperature of the bar and calculate the time required for the bar to cool to $30^0$C.

[7]

5. *Brevibacterium* ($C_8H_{13}O_4N$) is grown aerobically in a medium containing glucose for the production of lysine ($C_6H_{14}O_2N_2HCl$). The biomass growth rate and lysine production rate are 0.26 kg/m$^3$ h and 0.375 kg/m$^3$ h respectively. 40% of the substrate is used for growth and product formation. Estimate the fraction of substrate used for biomass and lysine production, yield of cell mass based on glucose and oxygen.

[7]

6. *S. cerevisiae* is grown anaerobically in continuous culture at $30^0$C. Glucose is used as carbon source ; ammonia is the nitrogen source. A mixture of glycerol and ethanol is produced. At steady state, mass flow to and from the reactor are asfollows:

| | |
|---|---|
| Glucose in | 36 kg/h |
| $NH_3$ in | 0.4 kg/h |
| Cells out | 2.81 kg/h |
| Glycerol out | 7.94 kg/h |
| Ethanol out | 11.9 kg/h |
| $CO_2$ out | 13.6 kg/h |
| $H_2O$ out | 0.15 kg/h |

Estimate the cooling requirements.

[8]