Bioreactors
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Lecture – 19
Solution to pp 5.1

Welcome to lecture number 19, NPTEL online certification course on bioreactors.

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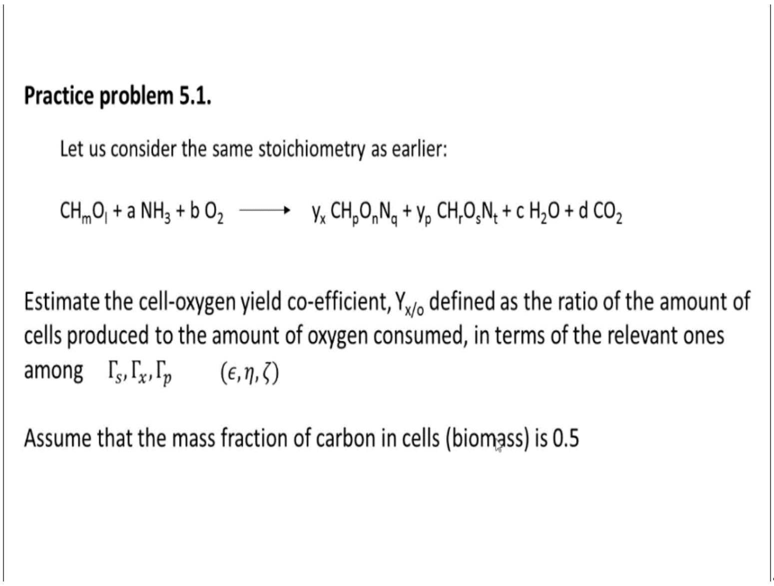

Practice problem 5.1.

For the following equation

$$CH_mO_l + a\ NH_3 + b\ O_2 \rightarrow y_x\ CH_pO_nN_q + y_p\ CH_rO_sN_t + c\ H_2O + d\ CO_2$$

Estimate the cell-oxygen yield co-efficient, $Y_{x/o}$ defined as the ratio of the amount of cells produced to the amount of oxygen consumed, in terms of the relevant ones among $\Gamma_s,\ \Gamma_x,\ \Gamma_p\ \ (\epsilon,\ \eta,\ \zeta)$.

Assume that the mass fraction of carbon in cells (biomass) is 0.5

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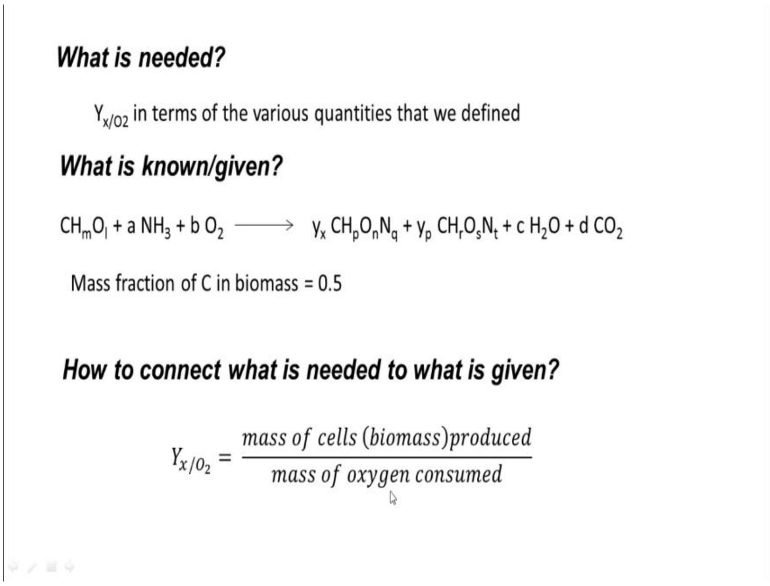

What is needed, our usual first question; Y x/O_2 in terms of the various quantities that we have defined is what we need. What is known, or given, the stoichiometric equation is known; the mass fraction of carbon in biomass is 0.5. And, how do we connect what is needed to what is given. We know that Y x/O_2, yield of cells with respect to oxygen, by definition is mass of cells or biomass produced, divided by the mass of oxygen that is consumed.

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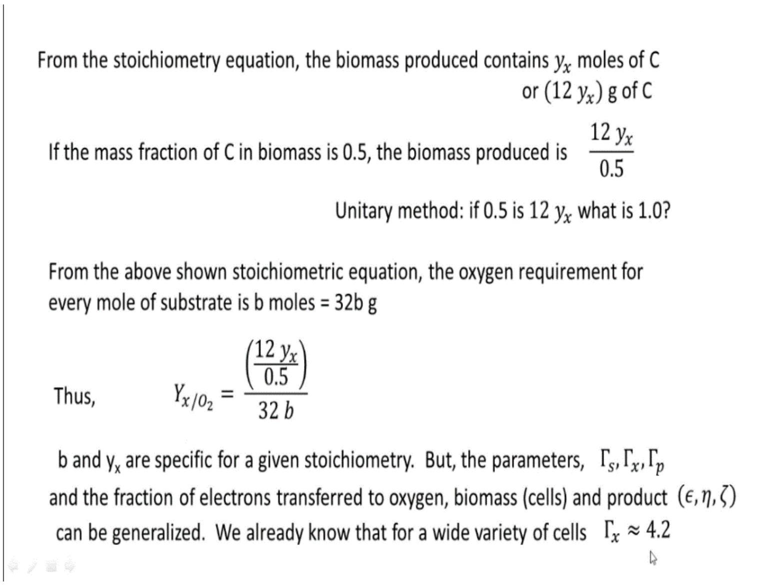

From the stoichiometric equation,

the biomass produced contains y_x moles of C, or 12 y_x grams of C.

If the mass fraction of C in biomass is 0.5, the biomass produced is $\frac{12y_x}{0.5}$

Also from the stoichiometric equation, we can derive that the oxygen requirement for every mole of substrate is b moles which when converted to mass is 32b grams.

Thus we can write

$$Y_{\frac{x}{O_2}} = \frac{\frac{12y_x}{0.5}}{32b}$$

b and y_x are specific for a given stoichiometry but $\Gamma_s,\ \Gamma_x,\ \Gamma_p,\ \epsilon,\ \eta,\ \zeta$ can be generalized.

We already know that, for a variety of cells Γ_x = 4.2.

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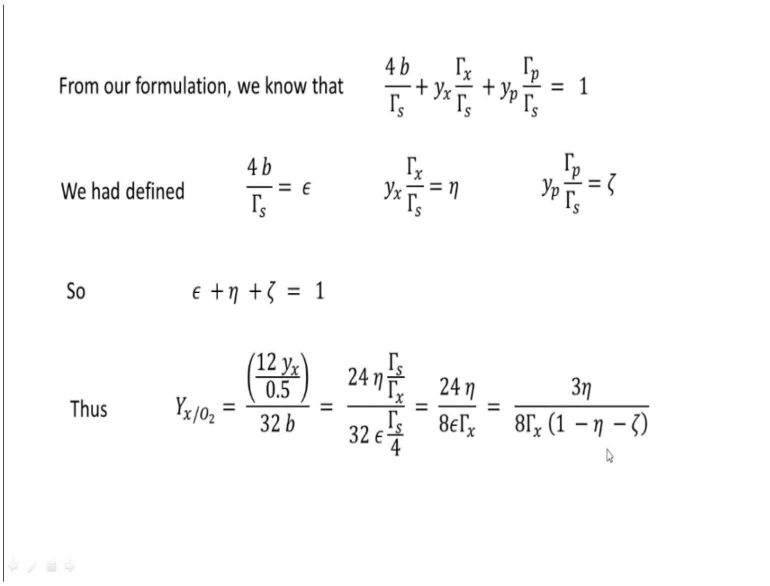

From our formulation, we know that

$$4b/\Gamma s \quad + \quad y_x\ \Gamma_x/\Gamma_s \quad + \quad y_p\ \Gamma_p/\Gamma_s \quad = \quad 1 \quad \text{or}$$

$$\varepsilon \quad + \quad \eta \quad + \quad \zeta \quad = \quad 1$$

We saw above that

$$Y_{\frac{x}{O_2}} = \frac{\frac{12y_x}{0.5}}{32b}$$

Substitute for y_x and b in terms of η and ε respectively to get

$$Y_{\frac{x}{O_2}} = \frac{\frac{12y_x}{0.5}}{32b} = \frac{24\eta\frac{\Gamma s}{\Gamma x}}{32\varepsilon\frac{\Gamma s}{4}} = \frac{24\eta}{8\varepsilon\Gamma x}$$

After substituting for ε, we get,

$$Y_{\frac{x}{O_2}} == \frac{3\eta}{\Gamma\mathrm{x}\,(1 - \eta - \zeta)}$$

Therefore, oxygen uptake rates can be estimated from biomass formation data.