Bioreactors

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Lecture – 11
Solution to pp 3.1

Welcome to lecture number 11, the NPTEL online certification course on Bioreactors. In the last lecture, we had assigned a problem, a practice problem 3.1. Let us solve that in this particular lecture. The problem read, in a batch bioreactor the concentration after inoculation was 0.5 gram per liter. The lag phase usually lasts 20 minutes under these conditions assuming that the cell concentration at the start of the lag phase, the start of the log phase was not significantly different from that immediately after inoculation, a; estimate the time needed for it to reach 4 grams per liter. The specific growth rate for this organism under these conditions is 0.5-hour inverse and what is the time needed for the cell concentration to double in the log phase is part b. So, let us look at the solution, let me maximize this first and start looking at the solution.

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What is needed?

(a) Time needed to reach 4 g l^{-1} in batch growth

What is known/given?

Cell concentration just after inoculation = 0.5 g l^{-1} = x_0 (assume)

Specific growth rate in the log phase = 0.5 h^{-1} (constant)

Lag phase = 20 min = t_0

We will ask our same questions for close ended problems solving, what is needed. What is needed here is in part a, is the time required to reach 4 grams per liter in batch growth.

What is known or given, the cell concentration just after inoculation is 0.5 gram per liter. Therefore, that can be taken to be x naught, we are assuming that there is the not much of a change in cell concentration during the lag phase therefore, x naught which is the cell concentration at the beginning of the log phase is also taken to be 0.5 gram per liter.

The specific growth rate in the log phase is given as 0.5 hour inverse, which we are taking as a constant. The lag phase is 20 minutes, which is t zero and those are the things that are known.

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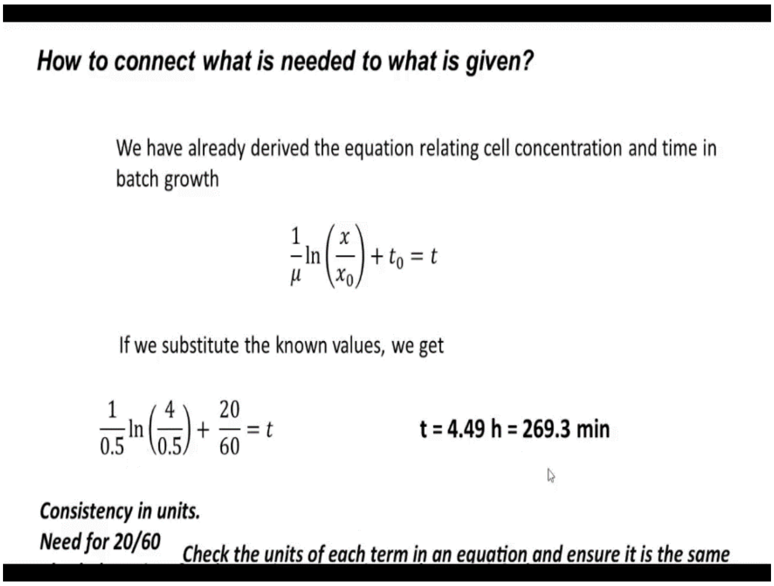

So, we have seen what is needed and what are known or given. Now, how to connect what is needed with what is known? We have already derived the equation relating the cell concentration and time in batch growth in the previous lecture. The equation was this 1 by mu, ln of x by x naught plus t zero equals the time, so we need time here.

$$\frac{1}{\mu}\ln\left(\frac{x}{x_0}\right)+t_0=t$$

If we substitute the known values, we get 1 by 0.5 mu, mu is constant 0.5 hour inverse, ln 4 by 0.5 plus t naught is 20 minutes and our specific growth rate was in hour inverse so we need to work with a consistent system of units. In other words, the units of each of these terms must be the same. If we check that, we will need to convert the 20 minutes into hours and therefore, we are dividing that by 60, 20 minutes by 60 minutes per hour is 1 third hour, that equals the time that is required.

We have checked for the consistency in unit, each term having the same system of units and the need for 20 by 60 we saw. It is always good to check the units of each term in an equation and ensure that it is the same. If we calculate this left-hand side, we will get t equals 4.49 hours or 269.3 minutes.

$$\frac{1}{0.5}\ln\left(\frac{4}{0.5}\right)+\frac{20}{60}=t=4.49\ hours=269.3\ minutes$$

So, this is part a, the time that is required to reach a concentration of 4 grams per liter starting with the concentration of 0.5 gram per liter, when the specific growth rate was 0.5 hour inverse.

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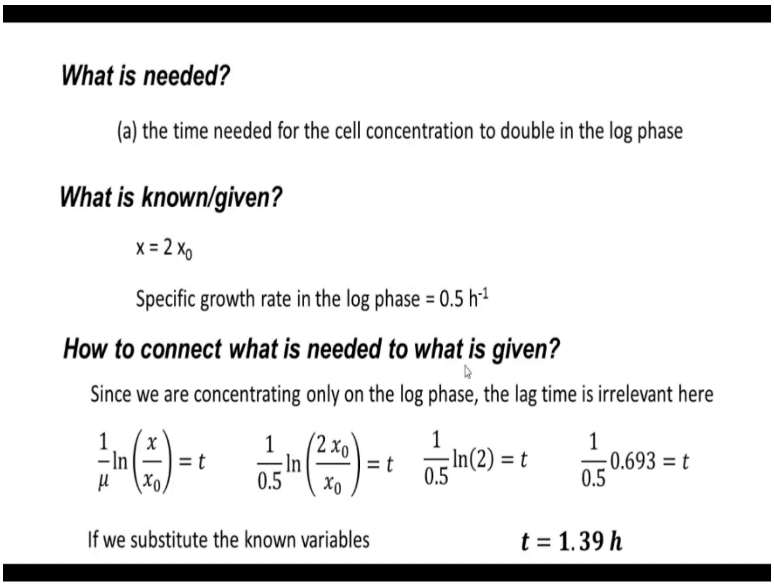

For part b what is needed? The time for the cell concentration to double in the log phase. What is known or given? This written in terms of our terminology would be x equals two times x naught. The specific growth rate is 0.5 hour inverse and how to connect what is needed to what is given? Since we are concentrating only on the log phase, the lag time is really irrelevant here. We do not have to worry about it.

Therefore, 1 by mu ln of x by x naught equals t, we do not have to worry about plus t naught which is actually the time from the beginning of the batch. So, we are concentrating only on the log phase here, if we substitute the known variables 1 by mu is 0.5, x of requirement here is 2 x naught by x naught, x naught, x naught can get canceled, this is ln 2. Therefore, ln 2 by 0.5 equals t, ln 2 is 0.693, 1 by 0.5 ln 2; 0.6. This is a nice number to remember 0.693, 0.693 by mu is a time that it usually takes to double. So, that would turn out to be t equals 1.39 hours.

$$\frac{1}{\mu}\ln\left(\frac{x}{x_0}\right) = t$$

$$\frac{1}{0.5}\ln\left(\frac{2x_0}{x_0}\right) = t$$

$$\frac{1}{0.5}\ln(2) = t$$

$$\frac{1}{0.5}\ (0.693) = t = 1.39\ hours$$

This was a straightforward solution; I am sure many of you would have gotten this and with practice we will become much better. I think we will stop this lecture, this is a short lecture, which kind of looks at the solution of the problem. When we begin the next lecture, we will take module 3 forward. See you then.