



Figure 9.6. Solution of Example 9.2 with a single stage, where  $\theta = 14$  h.

$0.143 \text{ h}^{-1}$ . The intersection of the reaction curve with the straight line determined by  $D_1(X_1 - X_0) = D_1X_1$  is the solution to eq. 9.24a. For the second stage, we consider the production phase and use eq. 9.26a. The predicted values of  $X_1$  and  $P_2$  are the same as in the first approach. Note that the  $dP/dt$ -versus- $P$  curve is displaced in time from the  $dX/dt$ -versus- $X$  curve. Consequently, we use the  $dX/dt$  plot before using the  $dP/dt$  plot.

### 9.3.3. Fed-batch Operation

In fed-batch culture, nutrients are continuously or semicontinuously fed, while effluent is removed discontinuously (Fig. 9.8). Such a system is called a *repeated fed-batch culture*. Fed-batch culture is usually used to overcome substrate inhibition or catabolite repression by intermittent feeding of the substrate. If the substrate is inhibitory, intermittent addition of the substrate improves the productivity of the fermentation by maintaining the substrate concentration low. Fed-batch operation is also called the semicontinuous system or variable-volume continuous culture. Consider a batch culture where the concentration of biomass at a certain time is given by

$$X = X_0 + Y_{X/S}^M (S_0 - S) \quad (9.27)$$