Question 2: Enzyme Kinetics

8.1. Using the law of mass action, write down four equations for the rate of changes of the four species, E, S, ES, and P.

Ans.

By the law of mass action, the rate of change is proportional to the product of the concentration of the reactants. The concentration of E, S, ES and P are set as [E], [S], [ES] and [P]. Assume the rate of change represents speed of increase

The rate of change of E:

$$\frac{d[E]}{dt} = k_2[ES] + k_3[ES] - k_1([E][S])$$

The rate of change of S:

$$\frac{d[S]}{dt} = k_2[ES] - k_1([E][S])$$

The rate of change of ES:

$$\frac{d[ES]}{dt} = k_1([E][S]) - k_2([ES]) - k_3([ES])$$

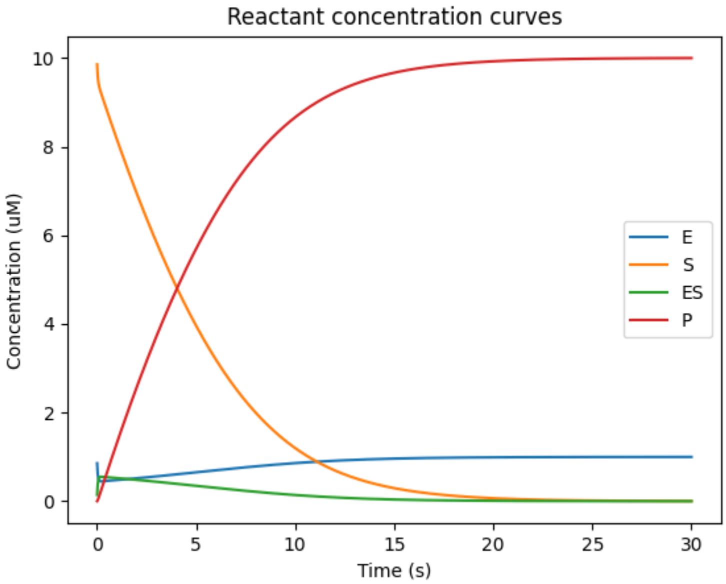
The rate of change of P:

$$\frac{d[P]}{dt} = k_3[ES]$$

8.2. Write a code to numerically solve these four equations using the fourth-order RungeKutta method. For this exercise, assume that the initial concentration of E is 1 μM, the initial concentration of S is 10 μM, and the initial concentrations of ES and P are both 0. The rate constants are: k1=100/μM/min, k2=600/min, k3=150/min.

Ans.

The coding steps of this question is shown in this folder with name ‘Enzyme_Kinetics.py’, and result figure is:



8.3. We define the velocity, V, of the enzymatic reaction to be the rate of change of the product P. Plot the velocity V as a function of the concentration of the substrate S. You should find that, when the concentrations of S are small, the velocity V increases approximately linearly. At large concentrations of S, however, the velocity V saturates to a maximum value, Vm. Find this value Vm from your plot.

Ans.
The maximum value of velocity V is 2.385 μM/s, code of which can be found in this file named by 'Enzyme_Kinetics.py'. The velocity curve is shown in picture below: