Question 2: Enzyme Kinetics

8.1.

the law of mass action：

The reaction rate of the elementary reaction is directly proportional to the product of the power of the concentration of each reactant.

The rate of change is expressed as V.

The concentration is expressed as C.

$$E + S \underset{k_2}{\overset{k_1}{\rightleftharpoons}} ES \xrightarrow{k_3} E + P$$

$$V_E = k_2 C_{ES} + k_3 C_{ES} - k_1 C_E C_S$$

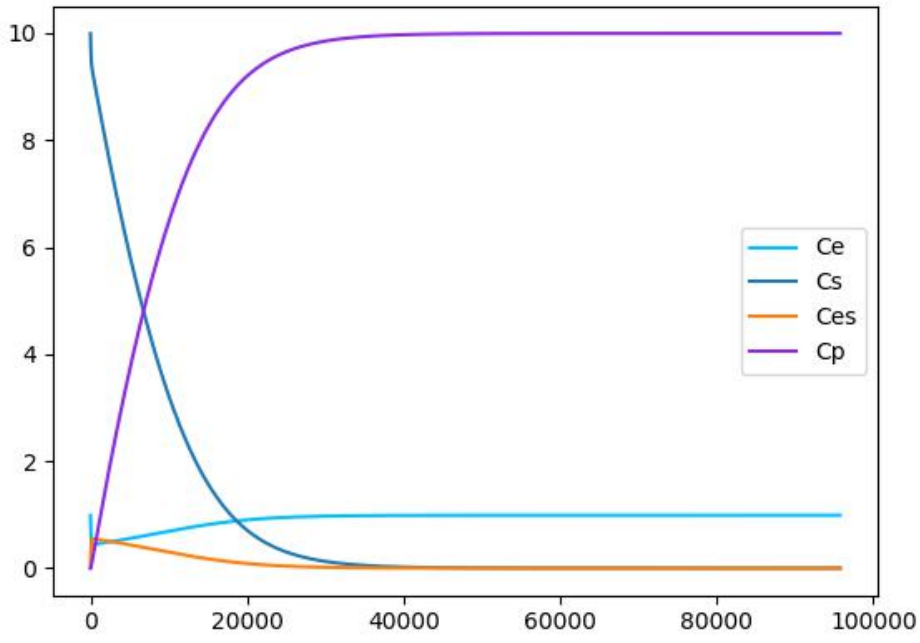
$$V_S = k_2 C_{ES} - k_1 C_E C_S$$

$$V_{ES} = k_1 C_E C_S - k_2 C_{ES} - k_3 C_{ES}$$

$$V_P = k_3 C_{ES}$$

8.2.

I used Python to simulate the whole reaction process according to the given parameters.



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8.3.

In order to find the maximum value of V_P,

I take $V_S = 0$: C_S doesn't change.

$\because V_S = k_2 C_{ES} - k_1 C_E C_S$

$\therefore \nexists\ k_2 C_{ES} = k_1 C_E C_S$

Define "sum" ↳S as the total concentration of E.

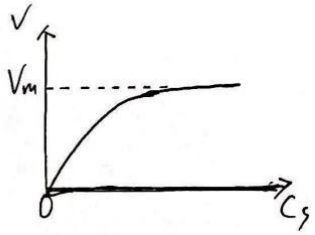
Because "sum" ↳S is a fixed and unchanging value,

$\therefore C_{ES} + C_E = \text{sum}\ S$

$\therefore C_E = S - C_{ES}$

$\therefore k_2 C_{ES} = k_1 C_S (S - C_{ES})$

$$C_{ES} = \frac{S k_1 C_S}{k_1 C_S + k_2}$$



$\because V = V_P = k_3 C_{ES}$

$$\therefore V = \frac{k_1 k_3 S C_S}{k_2 + k_1 C_S} = k_3 S \cdot \frac{C_S}{\frac{k_2}{k_1} + C_S} < k_3 S$$

So, $V_m = k_3 S$ (S is the total amount of E)