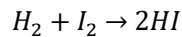


Q2

Answer 1

According to the information I got from the Internet, the law of mass action is expressed as follows: the rate of the reaction of the radicals is proportional to the product of the powers of the concentrations of the reactants, and the formula is expressed as follows,



The positive reaction rate for this reaction is,

$$v = k_1[H_2][I_2]$$

According to the law of mass action, the four equations are expressed as follows,

$$\frac{d[E]}{dt} = (k_2 + k_3) * [ES] - k_1[E][S] \quad (1)$$

$$\frac{d[S]}{dt} = k_2[ES] - k_1[S][E] \quad (2)$$

$$\frac{d[ES]}{dt} = k_1[E][S] - (k_2 + k_3) * [ES] \quad (3)$$

$$\frac{d[P]}{dt} = k_3[ES] \quad (4)$$

Answer 2

The fourth order Runge-Kutta equation is expressed as follows,

$$y' = f(t, y) \quad y(t_0) = y_0 \quad (1)$$

$$k_1 = f(t_n, y_n) \quad (2)$$

$$k_2 = f\left(t_n + \frac{h}{2}, y_n + \frac{h}{2} * k_1\right) \quad (3)$$

$$k_3 = f\left(t_n + \frac{h}{2}, y_n + \frac{h}{2} * k_2\right) \quad (4)$$

$$k_4 = f(t_n + h, y_n + h * k_3) \quad (5)$$

$$y_{n+1} = y_n + \frac{h}{6}(k_1 + 2k_2 + 2k_3 + k_4) \quad (6)$$

I implemented the fourth order Runge Kutta method using the C++ programming language, setting the step size to 0.00001, and after 100,000 iterations, the result is as follows,

E: 0.991771 S: 4.64927e-07 ES: 6.29773e-08 P: 9.99677

It can be seen that the enzyme is barely consumed, while the substrate S is almost completely consumed, generating a large amount of the product P.

Answer 3

According to the law of mass action, the velocity V given in the question is mainly determined due to the concentration of the product ES . The rate of ES production is $v_{produce} = k_1[E][S]$, and the rate of decomposition of the ES is $v_{decomposition} = k_3[ES] + k_2[ES]$. According to the information I found on the Internet, when reaching steady state, the two speeds should be equal, and so we get $k_1[E][S] = k_3[ES] + k_2[ES]$.

According to the information I checked on the Internet because enzymes are not consumed during the reaction, I set the total amount of enzymes is E_t . The above equation can be rewritten as,

$$k_1(E_t - [ES])[S] = k_3[ES] + k_2[ES]. \text{ The final simplification yields } [ES] = \frac{k_1 E_t [S]}{k_1 [S] + k_3 + k_2} =$$

$$\frac{E_t [S]}{[S] + \frac{k_2 + k_3}{k_1}}. \text{ According to the law of mass action, the product P is produced at a rate of } V_p = k_3[ES] =$$

$$\frac{k_3 E_t [S]}{[S] + \frac{k_2 + k_3}{k_1}}. \text{ For a chemical reaction, } \frac{k_2 + k_3}{k_1} \text{ is a constant. When the substrate S is very large, this time}$$

$$\text{satisfies, } \frac{k_2 + k_3}{k_1 [S]} \approx 0. \text{ So after processing the original formula we get } V_p = \frac{k_3 E_t}{1 + \frac{k_2 + k_3}{k_1 [S]}} \approx k_3 E_t. \text{ So the}$$

$$V_m = k_3 E_t$$