8.1.

SOLUTION Suppose the total concentration of the enzyme is $[E_0]$ and $[S] = x$,

$$V_P = V_0 = k_3[ES]$$

$$V_{ES} = V_{ES}(\text{synthesis}) - V_{ES}(\text{decomposition})$$

$$= k_1([E_0]-[ES])([S]) - (k_2+k_3)[ES]$$

Similarly,

$$V_E = k_1([E_0]-[ES])([S]) - (k_2+k_3)[ES]$$

$$V_S = k_1([E_0]-[ES])([S]) - k_2[ES]$$

Since the reaction is in steady state, so

$$V_{ES}(\text{synthesis}) = V_{ES}(\text{decomposition})$$

i.e. $k_1([E_0]-[ES])[S] = (k_2+k_3)[ES]$

Simplifying the equation gives

$$[ES] = \frac{[E_0][S]}{[S]+(k_2+k_3)/k_1}$$

Let K_m (Michaelis Constant) $= \dfrac{k_2+k_3}{k_1}$, then

$$[ES] = \frac{[E_0][S]}{K_m+[S]}$$

Since $V_P = k_3[ES]$, so

$$V_P = \frac{k_3[E_0][S]}{K_m+[S]} = \frac{k_3[E_0]x}{K_m+x}, \quad K_m = \frac{k_2+k_3}{k_1}$$

Summarizing:

$$V_P = k_3[ES]$$

$$V_{ES} = k_1([E_0]-[ES])[S] - (k_2+k_3)[ES]$$

$$V_E = k_1([E_0]-[ES])[S] - (k_2+k_3)[ES]$$

$$V_S = k_1([E_0]-[ES])[S] - k_2[ES]$$

When the reaction is in steady state, we conclude that

$$[ES] = \frac{[E_0][S]}{K_m+[S]}, \quad K_m = \frac{k_2+k_3}{k_1}$$

Thus

$$V_P = \frac{k_3[E_0][S]}{K_m+[S]}$$

$$= \frac{k_3[E_0]x}{K_m+x}, \quad K_m = \frac{k_2+k_3}{k_1}$$