8.1

$$\frac{d[E]}{dt} = -K_1\,[S][E] + K_2\,[ES] + K_3\,[ES] \tag{1}$$

$$\frac{d[S]}{dt} = -K_1\,[E][S] + K_2\,[ES] \tag{2}$$

$$\frac{d[ES]}{dt} = K_1\,[S][E] - K_2\,[ES] - K_3\,[ES] \tag{3}$$

$$\frac{d[P]}{dt} = K_3\,[ES] \tag{4}$$

8.2

```
function RK4

clear;clc;
% define initial values
E0=1;
k3=150/60;

% define step width and initial values of C,S
h=0.001;        % step width is 0.001s
t=0:h:30;       % range is 0-30s
n=length(t);   % quantity of t
Y(1,1)=1;     % initial values of C put in matrix Y
Y(2,1)=10;      % initial values of S put in matrix Y
Y(3,1)=0;
Y(4,1)=0;

% define RK4 to find out the solution of E,S,ES,P
for k=1:n-1
    z1=f(t(k),Y(1:4,k));  % Y(1:2,k) means take the 1st and 2nd row of kth line
    z2=f(t(k)+h/2,Y(1:4,k)+z1*h/2);
    z3=f(t(k)+h/2,Y(1:4,k)+z2*h/2);
    z4=f(t(k)+h,Y(1:4,k)+z3*h);
    Y(1:4,k+1)=Y(1:4,k)+h*(z1+2*z2+2*z3+z4)/6; % iteration of Y
                                               % new C/S will be added into matrix Y
                                               % C to the 1st row, S to the 2nd row
end
E=Y(1,:);  % Y's 1st row
S=Y(2,:);  % Y's 2nd row
ES=Y(3,:);
P=Y(4,:);


% plot
figure(1);  % 1st picture
plot(t,E,t,S,t,ES,t,P,'LineWidth',3);  % x:t y:E,S,C,P
legend('E','S','ES','P');
title('Variation of Components Concentration');
xlabel('time/s');
ylabel('concentration/uM');

```

```
vp = k3.*ES;
figure(2);
plot(S,vp,'LineWidth',3);
title('Vp changed with the concentration of S');
xlabel('Sconcentration/uM');
ylabel('uM/s');
end

function F=f(t,Y)
% input t and matrix Y
% define variables
k1=100/60;
k2=600/60;
k3=150/60;
theta=k2+k3;

% define the equation we want to solve
E=Y(1,1);  % Y is a 1*2 matrix
S=Y(2,1);
ES=Y(3,1);
P=Y(4,1);
f1 = -k1*S*E+theta*ES;
f2 = -k1*S*E + k2*ES;
f3 = k1*S*E - theta*ES;
f4 = k3*ES;

F=[f1;f2;f3;f4];  % output of F is a matrix contain f1(C) and f2(S)
end
```

8.3