8.1
The equations are shown below.

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

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

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

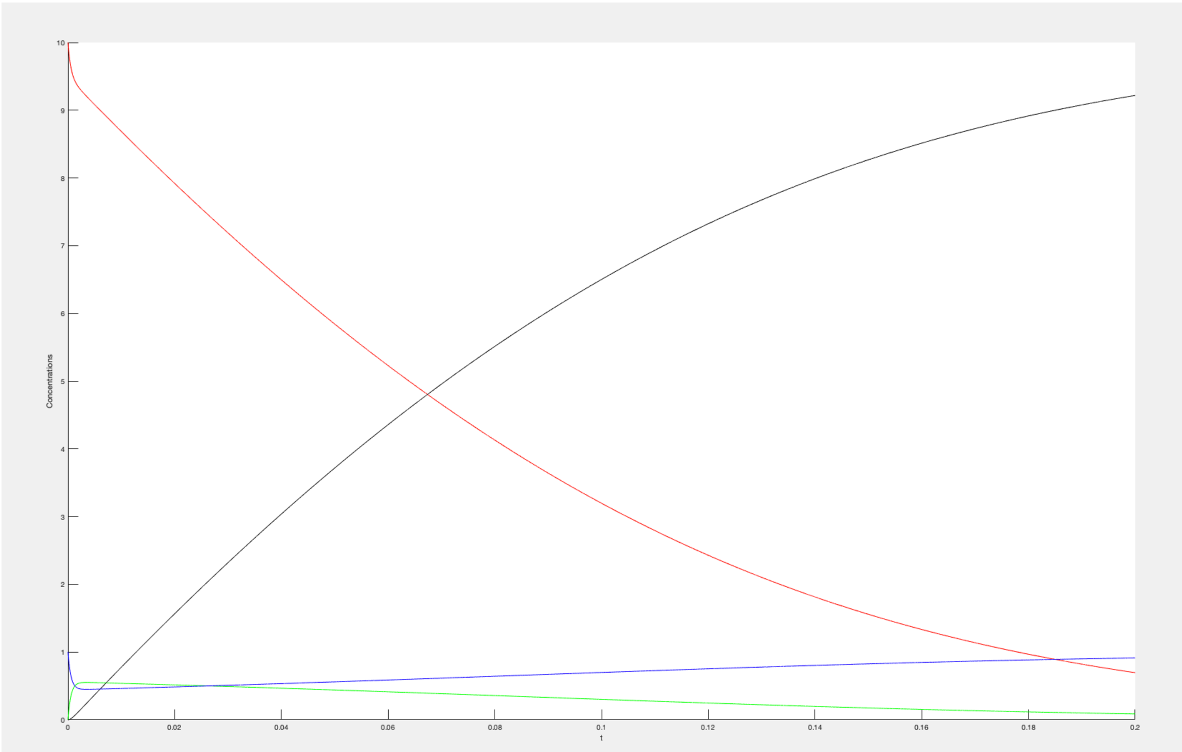
$$\frac{d[P]}{dt} = k_3[ES]$$

8.2
*Codes are written in matlab

```
function F=enzyme_Kinetics(t,Y)

S = Y(1);
ES = Y(2);
P = Y(3);

% Define rate constants
k1=100;
k2=600;
k3=150;

% Define the ordinary differential equations of the enzyme kinetics
dS = -k1*(1-ES)*S+k2*ES;
dES = k1*(1-ES)*S-k2*ES-k3*ES;
dP = k3*ES;

F=[dS;dES;dP];

end


% Define step size and initial value
Delta = 0.00001;
t = 0:Delta:0.2;
range = length(t);
Y(:,1)=[10;0;0];
```

```
% 4th order RK method
for n=1:range-1
    z1 = enzyme_Kinetics(t(n),Y(:,n));
    z2 = enzyme_Kinetics(t(n)+Delta/2,Y(:,n)+z1*Delta/2);
    z3 = enzyme_Kinetics(t(n)+Delta/2,Y(:,n)+z2*Delta/2);
    z4 = enzyme_Kinetics(t(n)+Delta,Y(:,n)+z3*Delta);
    Y(:,n+1) = Y(:,n)+Delta*(z1+2*z2+2*z3+z4)/6;
end

S = Y(1,:);
ES = Y(2,:);
P = Y(3,:);


% Plot the function figures of 4 species(E,S,ES,P)
figure;

hold on
plot(t,S,'r')
xlabel('t')
ylabel('Consentrations')

plot(t,ES,'g')
xlabel('t')
ylabel('Concentrations')

plot(t,P,'black')
xlabel('t')
ylabel('Concentrations')

plot(t,1-ES,'b')
xlabel('t')
ylabel('Concentrations')

hold off
```

The running results are shown in the figure below, red line indicates the concentrations of S; black line indicates the concentrations of P; blue line indicates the concentrations of E; green line indicates the concentration of ES.




8.3

*Codes are written in matlab

```
function V=michaelis_menten_equation(S)

% Define concentration of total enzyme
E0=1;

% Define rate constants
k1=100;
k2=600;
k3=150;

% Define the coefficients in Michaelis Menten equation
km=(k2+k3)/k1;
Vmax=k3*E0;

% Define the Michaelis Menten equation
V = (Vmax*S)/(km+S);
end

% Define step size and initial value
S = 0:0.01:600;
V=[];
```

```
for i = 1:length(S)
    V(i) = michaelis_menten_equation(S(i));
end

% Plot
figure
plot(S,V)
xlabel('Concentrations of S')
ylabel('Velocity')
```

The plot result is shown in the figure below. From this figure, we can see that when $k_3 = 150/min$ and $E_{total} = 1\mu M$ the maximum velocity, Vm, is around 150 $\mu M/min$.