(1)

Given:

V(S) shows the rate of changes of S, C(S) shows the concentration of S

V(ES) shows the rate of changes of ES, C(ES) shows the concentration of ES

V(P) shows the rate of changes of P, C(P) shows the concentration of P

V(E) shows the rate of changes of E, C(E) shows the concentration of E

According to the law of mass action and two-step process, we can write down the equation below:

$$
\begin{aligned}
&\mathrm{V}(S) = -k_1 \times C(E) \times C(S) + k_2 \times C(ES) \\
&V(ES) = k_1 \times C(E) \times C(S) - k_3 \times C(ES) - k_2 \times C(ES) \\
&V(P) = k_3 \times C(ES) \\
&V(E) = k_2 \times C(ES) + k_3 \times C(ES) - k_1 \times C(E) \times C(S)
\end{aligned}
$$

(2)

According to the law, it is obvious that(t means time):

$$\mathrm{V}(S) = \frac{d(C(S))}{d(t)}$$

$$V(ES) = \frac{d(C(ES))}{d(t)}$$

$$V(P) = \frac{d(C(P))}{d(t)}$$

$$V(E) = \frac{d(C(E))}{d(t)}$$

Then I used matlab to solve these four equations by using the forth-order Runge-Kutta method:

File1: main.m

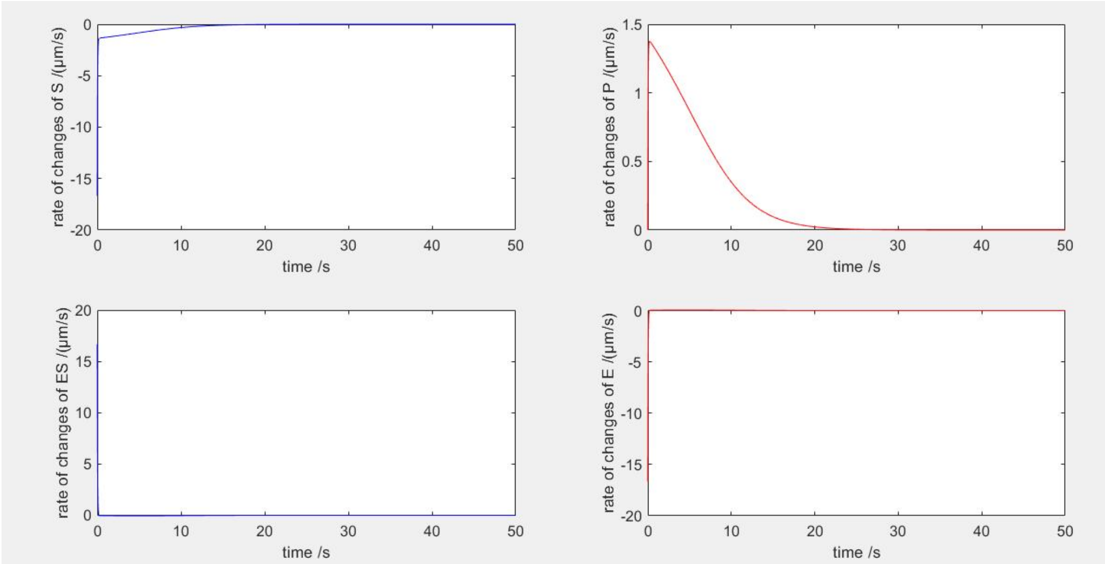
```
clear;clc;close all
Delta = 0.001;
%time (second)
t=0:Delta:50;
n=length(t);
%set the initial value
Y(:,1)=[10;0;0;1];

%forth-order Runge-Kutta method
for k=1:n-1
    z1=f(t(k),Y(:,k));
    z2=f(t(k)+Delta/2,Y(:,k)+z1*Delta/2);
    z3=f(t(k)+Delta/2,Y(:,k)+z2*Delta/2);
    z4=f(t(k)+Delta,Y(:,k)+z3*Delta);
    Y(:,k+1)=Y(:,k)+Delta*(z1+2*z2+2*z3+z4)/6;
end
```

```
%x:C(S)    y:C(ES)    m:C(P)    n:C(E)
x=Y(1,:);
y=Y(2,:);
m=Y(3,:);
n=Y(4,:);

%four figures delineate the velocity of four species as the time goes by
figure
set(gcf,'units','normalized','position',[0.15,0.2,0.7,0.6]);
subplot(2,2,1)
plot(t,-100/60*n.*x+600/60*y,'b')
xlabel('time /s')
ylabel('rate of changes of S /(μm/s)')

subplot(2,2,2)
plot(t,150/60*y,'r')
xlabel('time /s')
ylabel('rate of changes of P /(μm/s)')

subplot(2,2,3)
plot(t,100/60*n.*x-150/60*y-600/60*y,'b')
xlabel('time /s')
ylabel('rate of changes of ES /(μm/s)')

subplot(2,2,4)
plot(t,750/60*y-100/60*n.*x,'r')
xlabel('time /s')
ylabel('rate of changes of E /(μm/s)')
```

File2:f.m

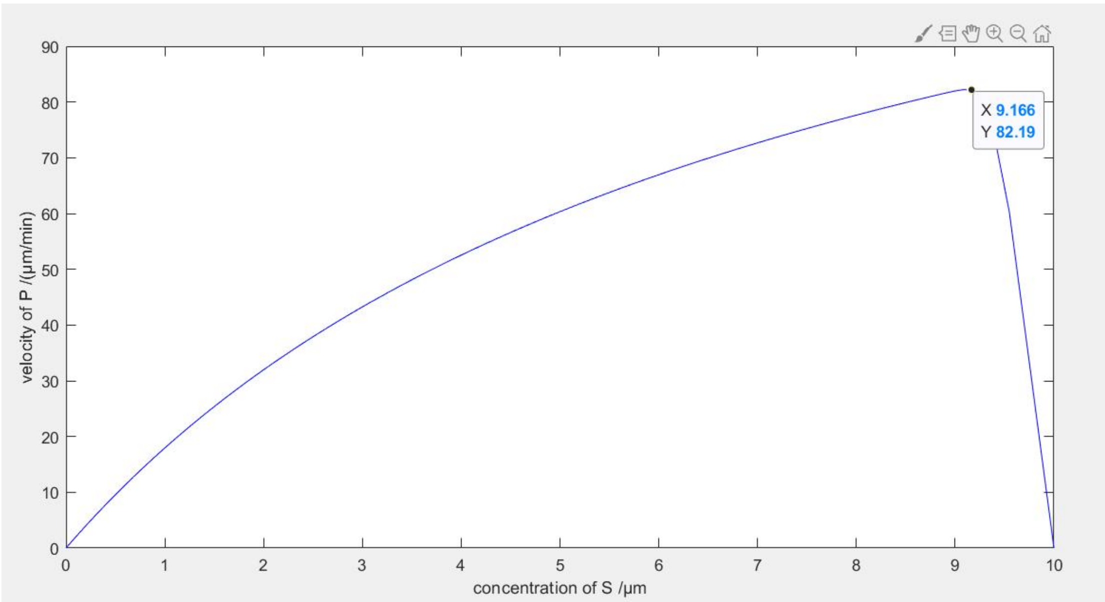
```
function F=f(t,Y)
x=Y(1);
y=Y(2);
m=Y(3);
n=Y(4);
%four equations of changing rate of four species(time unit:second)
f1=-100/60*n*x+600/60*y;
f2=100/60*n*x-150/60*y-600/60*y;
f3=150/60*y;
f4=750/60*y-100/60*n*x;
F=[f1;f2;f3;f4];
end
```

The outcome of the codes above:



Comment: Here I use the second as the time unit to draw the figures.

(3) Based on the second question, I get the figure by adjusting the code of figure part, the answer is below:



Vm = 82.19 µm/min, which is noted on the plot