1.

Notice: [E] represents the concentration of E

rate of changes of E: $k_2[ES] + k_3[ES] - k_1[E][S]$

rate of changes of S: $k_2[ES] - k_1[E][S]$

rate of changes of ES: $k_1[E][S]$- $k_2[ES] - k_3[ES]$

rate of changes of P: $k_3[ES]$

2.

First we can write the formula for the first question in code

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

E = Y(1);
S= Y(2);
ES = Y(3);
P = Y(4);
f1 = 750*ES-100*E*S;
f2 = 600*ES-100*E*S;
f3 = 100*E*S-750*ES;
f4 = 150*ES;
F=[f1;f2;f3;f4];
end
```

And give the initial value in the main function:

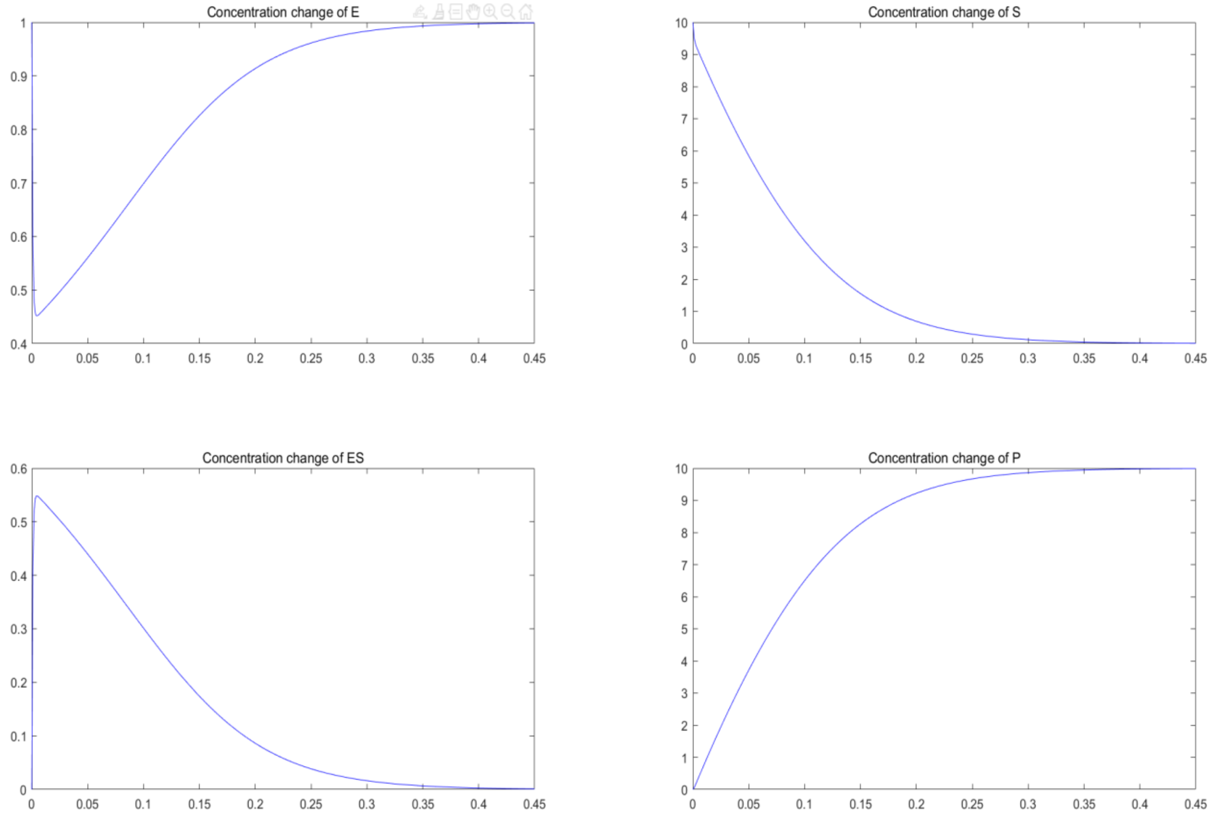
```
Y(:,1)=[1;10;0;0];
```

The screenshot below is the main function, which contains the fourth-order Runge Kutta method definition, setting the step size, drawing and so on.

```matlab
h = 0.000001;
t = 0:h:0.45;
n=length(t);
Y(:,1)=[1;10;0;0];

for i = 1:n-1

   K1 = f(t(i), Y(:,i));
   K2 = f(t(i)+h/2, Y(:,i)+K1*h/2);
   K3 = f(t(i)+h/2, Y(:,i)+K2*h/2);
   K4 = f(t(i)+h, Y(:,i)+K3*h);
   Y(:,i+1) = Y(:,i)+h/6*(K1+2*K2+2*K3+K4);
end
E=Y(1,:);
S=Y(2,:);
ES=Y(3,:);
P=Y(4,:);

figure
subplot(2,2,1)
plot(t,E,'b');
title('Concentration change of E')
subplot(2,2,2)
plot(t,S,'b');
title('Concentration change of S')
subplot(2,2,3)
plot(t,ES,'b');
title('Concentration change of ES')
subplot(2,2,4)
plot(t,P,'b');
title('Concentration change of P')
```

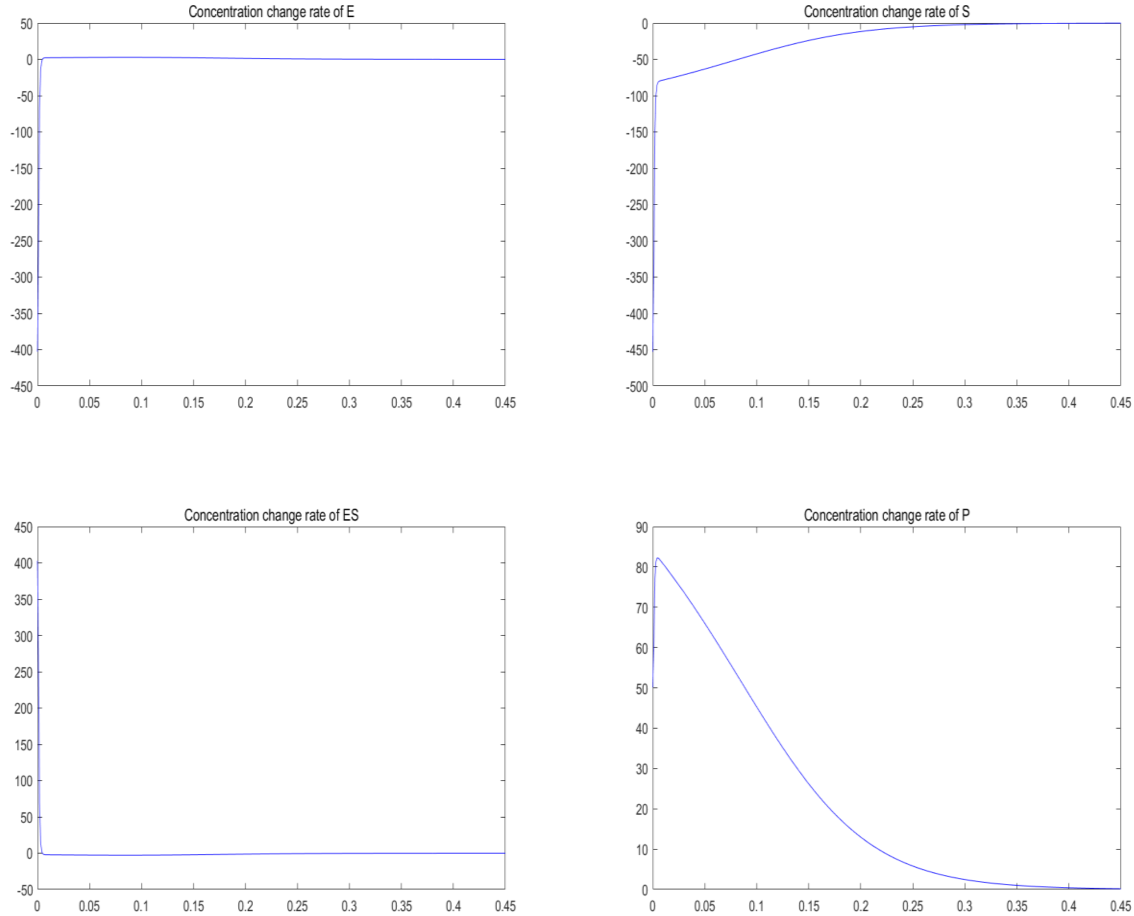
The Result:

The change in the concentration of four substances:



I take the derivative of the concentration and you get the rate of change of the concentration

Concentration change rate of four substances:



3.

$$V = \text{rate of changes of P} = k_3[ES] \quad (1)$$

And we can see from this that if we want to figure out V, we first have to figure out the concentration of ES

When the reaction is in equilibrium

The rate of changes of ES should be 0:

$$k_1[E][S] - k_2[ES] - k_3[ES] = 0 \quad \textbf{(2)}$$

And we can also know

$$[E_0] = [E]+[ES] \quad \textbf{(3)}$$

($[E_0]$ is the initial concentration of E)

With Equation (3), we can replace E in Equation (2) to get the following equation:

$$[ES] = \frac{k_1 [E_0][S]}{k_1[S]+k_2+k_3} \quad (4)$$

Combining Equation (4) and Equation (1) we can get:

$$V= \frac{k_1 k_3 [E_0][S]}{k_1[S]+k_2+k_3}=\frac{k_3 [E_0][S]}{[S]+\frac{k_2+k_3}{k_1}} \quad (5)$$

$\frac{k_2+k_3}{k_1}$ is a constant. When the concentration of S is very large, this constant term can be omitted. The value of Equation 5 will be close to the maximum.

$$V_{max} = k_3[E_0]$$