8.2

In [1]:
```
import numpy as np
# import mpmath
import matplotlib.pyplot as plt
%matplotlib inline
```

In [2]:
```
def funcXt(x, y, z, w):
    x=float(x)
    z=float(z)
    return -100*x*z + 750*y
```

In [3]:
```
def funcYt(x, y, z, w):
    x=float(x)
    z=float(z)
    return 100*x*z - 750*y
```

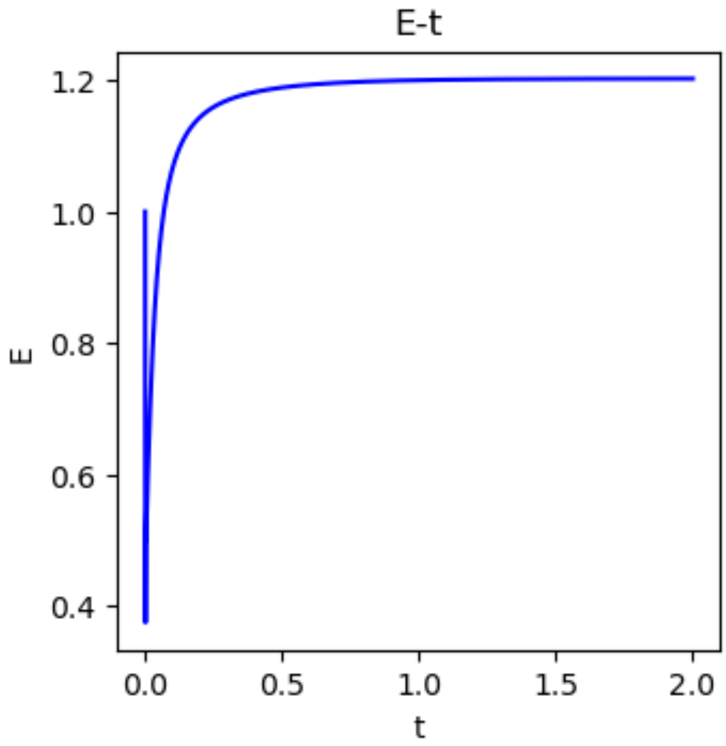
In [4]:
```
def funcZt(x, y, z, w):
    x=float(x)
    z=float(z)
    return -100*z + 600*y
```

In [5]:
```
def funcWt(x, y, z, w):
    x=float(x)
    z=float(z)
    return 150*y
```

In [6]:
```
### solve RK4
t_ini = 0                      # tmin
t_end = 2                      # tmax
t_h = 1e-3                     # step size

t = np.linspace(t_ini, t_end, int((t_end-t_ini)/t_h+1))
x = t.copy()
y = t.copy()
z = t.copy()
w = t.copy()
x[0] = 1
y[0] = 0
z[0] = 10
w[0] = 0

for i in range(t.shape[0]-1):
    h_i = t[i+1] - t[i]

    k1_x = funcXt(x[i], y[i], z[i], w[i])
    k1_y = funcYt(x[i], y[i], z[i], w[i])
    k1_z = funcZt(x[i], y[i], z[i], w[i])
    k1_w = funcWt(x[i], y[i], z[i], w[i])

    k2_x = funcXt(x[i]+h_i/2*k1_x, y[i], z[i], w[i])
    k2_y = funcYt(x[i], y[i]+h_i/2*k1_y, z[i], w[i])
    k2_z = funcZt(x[i], y[i], z[i]+h_i/2*k1_z, w[i])
    k2_w = funcWt(x[i], y[i], z[i], w[i]+h_i/2*k1_w)

    k3_x = funcXt(x[i]+h_i/2*k2_x, y[i], z[i], w[i])
    k3_y = funcYt(x[i], y[i]+h_i/2*k2_y, z[i], w[i])
    k3_z = funcZt(x[i], y[i], z[i]+h_i/2*k2_z, w[i])
    k3_w = funcWt(x[i], y[i], z[i], w[i]+h_i/2*k2_w)

    k4_x = funcXt(x[i]+h_i*k3_x, y[i], z[i], w[i])
    k4_y = funcYt(x[i], y[i]+h_i*k3_y, z[i], w[i])
    k4_z = funcZt(x[i], y[i], z[i]+h_i*k3_z, w[i])
    k4_w = funcWt(x[i], y[i], z[i], w[i]+h_i*k3_w)

    x[i+1] = x[i] + h_i/6*(k1_x+2*k2_x+2*k3_x+k4_x)
    y[i+1] = y[i] + h_i/6*(k1_y+2*k2_y+2*k3_y+k4_y)
    z[i+1] = z[i] + h_i/6*(k1_z+2*k2_z+2*k3_z+k4_z)
    w[i+1] = w[i] + h_i/6*(k1_w+2*k2_w+2*k3_w+k4_w)
```

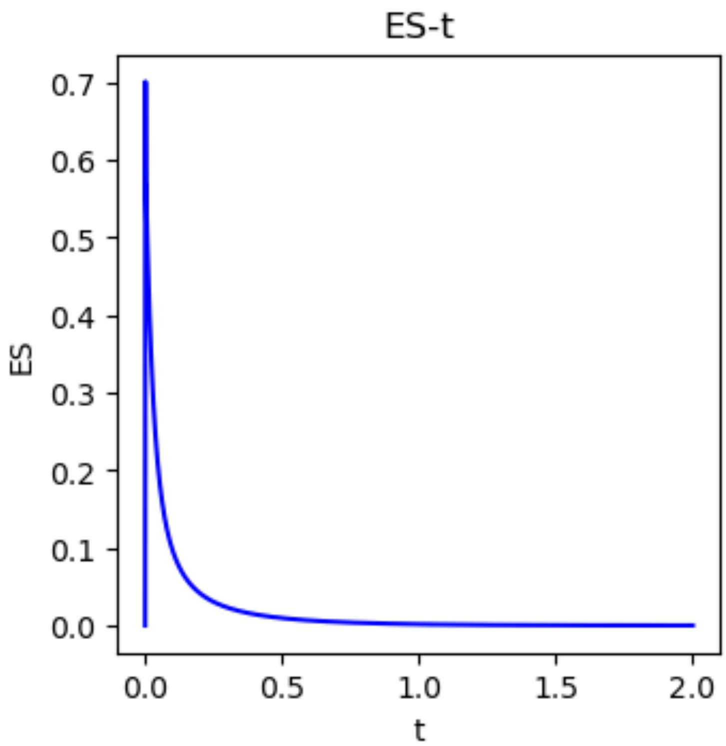
In [7]:
```
plt.figure(figsize=(8, 8))
plt.subplot(2, 2, 1)
plt.plot(t, x, 'b')
plt.xlabel('t')
plt.ylabel('E')
plt.title('E-t')
```

Out[7]:
```
Text(0.5, 1.0, 'E-t')
```



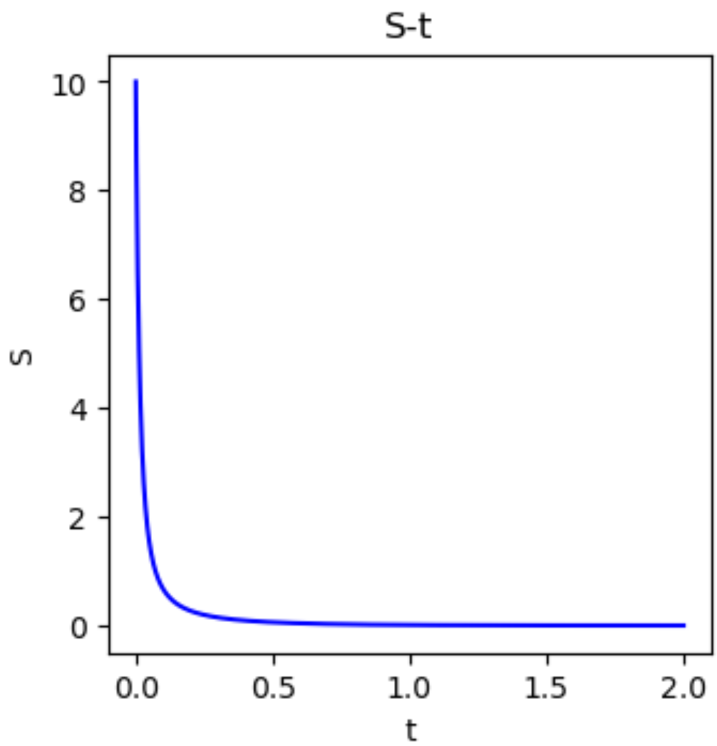
In [8]:
```
plt.figure(figsize=(8, 8))
plt.subplot(2, 2, 2)
plt.plot(t, y, 'b')
plt.xlabel('t')
plt.ylabel('ES')
plt.title('ES-t')
```

Out[8]:
```
Text(0.5, 1.0, 'ES-t')
```



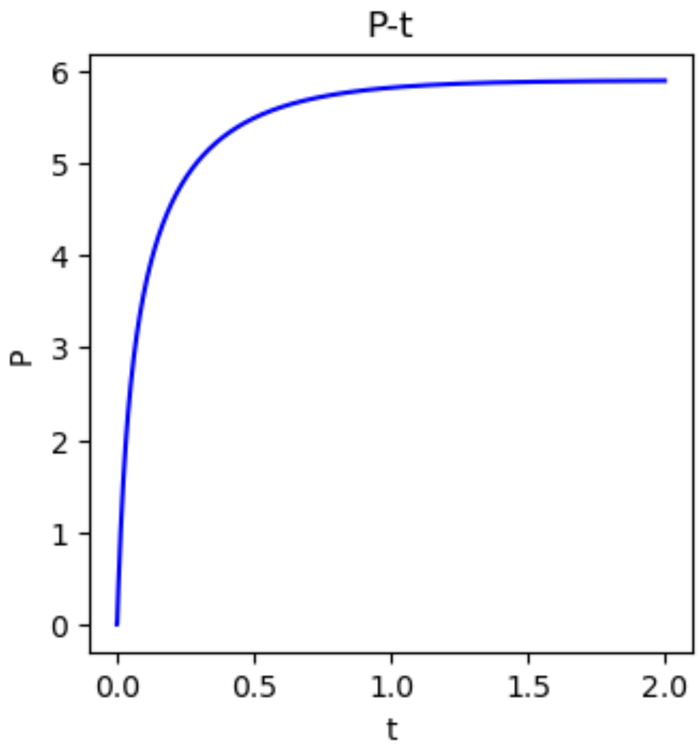
In [9]:
```
plt.figure(figsize=(8, 8))
plt.subplot(2, 2, 3)
plt.plot(t, z, 'b')
plt.xlabel('t')
plt.ylabel('S')
plt.title('S-t')
```

Out[9]:
```
Text(0.5, 1.0, 'S-t')
```



In [10]:
```
plt.figure(figsize=(8, 8))
plt.subplot(2, 2, 4)
plt.plot(t, w, 'b')
plt.xlabel('t')
plt.ylabel('P')
plt.title('P-t')
```

Out[10]:
```
Text(0.5, 1.0, 'P-t')
```



8.3

Main Idea

As the chemical reaction starts when V represents the change rate of P, V reaches its max, Vm, because the concentration of S is the biggest in the beginning of reaction. Then V is supposed to decrease slowly (Vm refers to the reaction rate when the enzyme is completely saturated with the substrate). And basically, this is a chemical reaction from S to P, catalyzed by E.