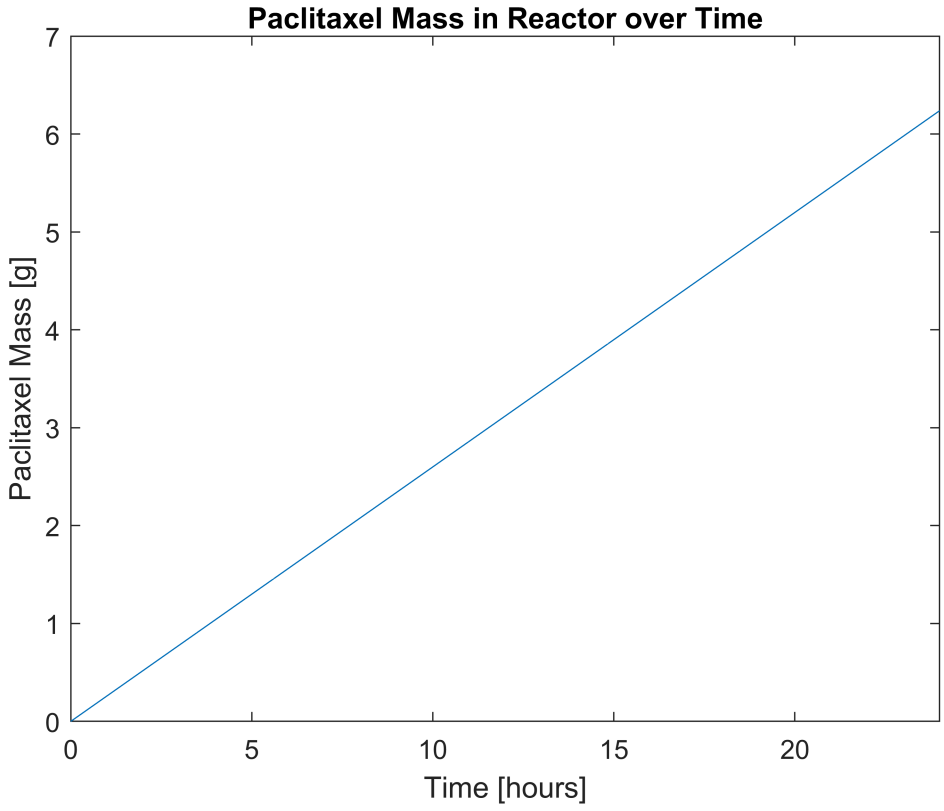
Iteration I

```
clear;
% Constants and Initial Conditions
F1 = 0; % [L/h]
C1 = 5; % [g/L]
F2 = 0; % [L/h]
V = 1; % [L]
T = 273 + 30; % [K]
cp = 4.186; % [J/g-K]

e = 2; % [g/L]
s = 2; % [g/L]
rho_cell = 200; % [g/L]
Vs1 = e * V / rho_cell; % [L]
Vs2 = s * V / rho_cell; % [L]
rho_water = 1000; % g/L

x = 5; % [g/L]
p = 0; % [g/L]
d = 0; % [g/L]
a = 0; % [g/L]

Wx = 150.13; % [g/mol]
Wd = 272.476; % [g/mol]
Wa = 60.052; % [g/mol]
Wp = 853.906; % [g/mol]

Hxd = 15; % [J/mol]
Hxa = 7; % [J/mol]
Hxe = 0; % [J/mol]
Hdp = 8; % [J/mol]
Has = 0; % [J/mol]

m = (e + s + x + p + d + a) * V; % [g]
ms1 = e; % [g]
ms2 = s; % [g]



time = 0:0.01:24; % [h]
p_t = zeros(length(time),1);
i = 1;
delt = 0.01;

for i = 1:length(time)
    p_t(i) = p; % [g]
    rxe = 0;
    rxd = 1 / (1/0.65 + 1/0.57 + 1/0.891 + 1/0.078 + 1/0.52 + 1/0.134 + 1/0.0003 + 1/506 + 1/2 ...
        + 1/0.0035 + 1/0.06 + 1/0.06 + 1/0.00000133 + 1/0.109 + 1/3 + 1/1.6 + 1/23 + 1/33 ...
        + 1/0.75 + 1/0.099 + 1/0.03); % [mol/L-min]
    rxd = rxd * 60; % [mol/L-h]
    rxa = 1 / (1/0.65 + 1/0.57 + 1/0.891 + 1/0.078 + 1/0.52 + 1/0.134 + 1/0.885); % [mol/L-min]
    rxa = rxa * 60; % [mol/L-h]
    rdp = 1 / (1/0.016 + 1/5.77 + 1/0.00635 + 1/6.1 + 1/2.2 + 1/0.0049 + 1/0.0049); % [mol/L-min]
    rdp = rdp * 60; % [mol/L-h]
    ras = 0;
```

```
% integrate dxdt = F1 * C1 - (rxe + rxd + rxa) * Wx * Vs1; % [g/h]
x = x + F1 * C1 * delt - (rxe + rxd + rxa) * Wx * Vs1 * delt; % [g]
if x < 0
    x = 0;
end
% integrate dddt = rxd * Wx * Vs1 - rdp * Wd * Vs2; % [g/h]
d = d + rxd * Wx * Vs1 * delt - rdp * Wd * Vs2 * delt; % [g]
if d < 0
    d = 0;
end
% integrate dadt = rxa * Wx * Vs1 - ras * Wa * Vs2; % [g/h]
a = a + rxa * Wx * Vs1 * delt - ras * Wa * Vs2 * delt; % [g]
if a < 0
    a = 0;
end
% integrate dedt = rxe * Wx * Vs1; % [g/h]
e = e + rxe * Wx * Vs1 * delt; % [g]
if e < 0
    e = 0;
end
% integrate dsdt = ras * Wa * Vs2; % [g/h]
s = s + ras * Wa * Vs2 * delt;
if s < 0
    s = 0;
end
C2 = p / V; % [g/L]
% integrate dpdt = rdp * Vs2 - F2 * C2
p = p + rdp * Vs2 * Wd * delt - F2 * C2 * delt; % [g]
if p < 0
    p = 0;
end

% integrate dmdt = F1 * C1 - F2 * C2; % [g/h]
m = m + F1 * C1 * delt - F2 * C2 * delt; % [g]
if m < 0
    m = 0;
end
% integrate dms1dt = F1 * C1 - Vs1 * Wx * (rxd + rxa); % [g/h]
ms1 = ms1 + F1 * C1 * delt - Vs1 * Wx * (rxd + rxa) * delt; % [g]
if ms1 < 0
    ms1 = 0;
end
% integrate dms2dt = Vs1 * Wx * (rxd + rxa) - F2 * C2; % [g/h]
ms2 = ms2 + Vs1 * Wx * (rxd + rxa) * delt - F2 * C2 * delt; % [g]
if ms2 < 0
    ms2 = 0;
end

% Assuming Subsystems Maintain a constant temperature
% dhs1dt = Vs1 * (Hxd * Wd * rxd + Hxa * Wa * rxa + Hxe * We * rxe) - F6
F6 = Vs1 * Wx * (Hxd * rxd + Hxa * rxa + Hxe * rxe);
if F6 < 0
    F6 = 0;
end
% dhs2dt = Vs2 * (Hdp * Wp * rdp + Has * Ws * ras) - F7
F7 = Vs2 * (Hdp * Wd * rdp + Has * Wa * ras);
if F7 < 0
    F7 = 0;
```

```
    end

    % Assume F3 = 0
    F3 = 0; % [J/h]
    dhdt = F6 + F7 - F3;
    if dhdt < 0
        dhdt = 0;
    end
    T = T + dhdt / (e + s + (rho_water - (e + s)) * V * cp); % [K]
end

plot(time, p_t)
title('Paclitaxel Mass in Reactor over Time')
xlabel('Time [hours]')
xlim([0,24])
ylabel('Paclitaxel Mass [g]')
```



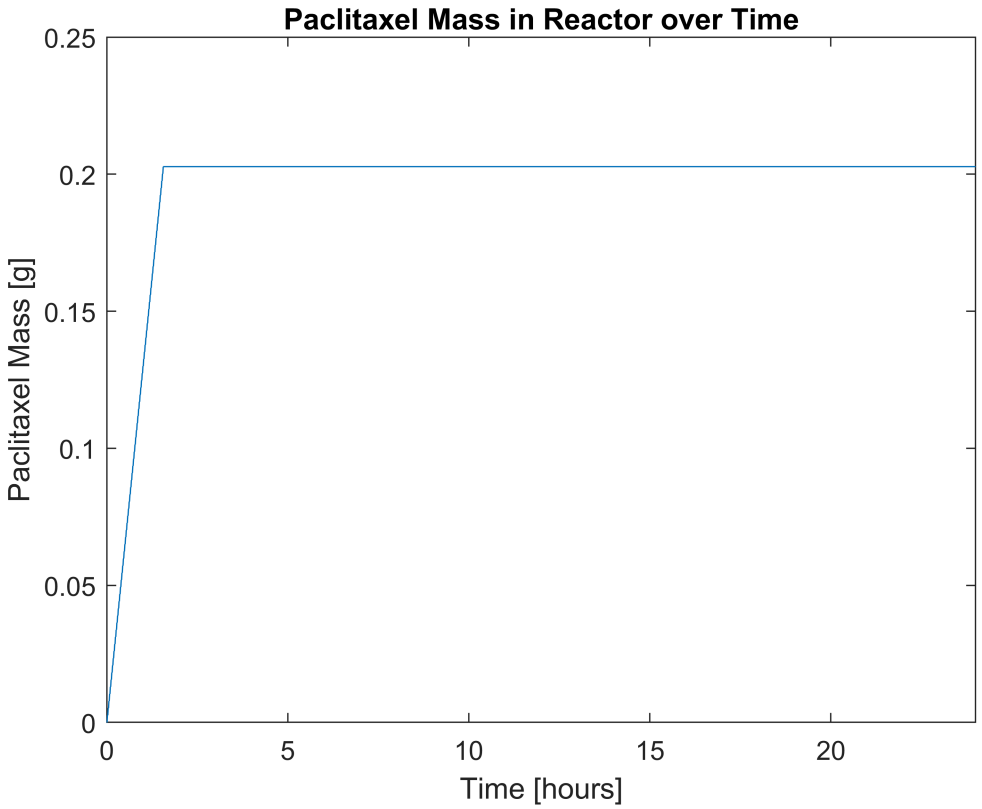
Iteration II

```
clear;
% Constants and Initial Conditions
F1 = 0; % [L/h]
C1 = 5; % [g/L]
F2 = 0; % [L/h]
V = 1; % [L]
T = 273 + 30; % [K]
cp = 4.186; % [J/g-K]

e = 2; % [g/L]
```

```
s = 2; % [g/L]
rho_cell = 200; % [g/L]
Vs1 = e * V / rho_cell; % [L]
Vs2 = s * V / rho_cell; % [L]
rho_water = 1000; % g/L

x = 5; % [g/L]
p = 0; % [g/L]
d = 0; % [g/L]
a = 0; % [g/L]

Wx = 150.13; % [g/mol]
Wd = 272.476; % [g/mol]
Wa = 60.052; % [g/mol]
Wp = 853.906; % [g/mol]

Hxd = 15; % [J/mol]
Hxa = 7; % [J/mol]
Hxe = 0; % [J/mol]
Hdp = 8; % [J/mol]
Has = 0; % [J/mol]

m = (e + s + x + p + d + a) * V; % [g]
ms1 = e; % [g]
ms2 = s; % [g]



time = 0:0.01:24; % [h]
p_t = zeros(length(time),1);
i = 1;
delt = 0.01;

for i = 1:length(time)
    p_t(i) = p; % [g]
    rxe = 0;
    rxd = 1 / (1/0.65 + 1/0.57 + 1/0.891 + 1/0.078 + 1/0.52 + 1/0.134 + 1/0.0003 + 1/506 + 1/2 ...
        + 1/0.0035 + 1/0.06 + 1/0.06 + 1/0.00000133 + 1/0.109 + 1/3 + 1/1.6 + 1/23 + 1/33 ...
        + 1/0.75 + 1/0.099 + 1/0.03); % [mol/L-min]
    rxd = rxd * 60; % [mol/L-h]
    rxa = 1 / (1/0.65 + 1/0.57 + 1/0.891 + 1/0.078 + 1/0.52 + 1/0.134 + 1/0.885); % [mol/L-min]
    rxa = rxa * 60; % [mol/L-h]
    rdp = 1 / (1/0.016 + 1/5.77 + 1/0.00635 + 1/6.1 + 1/2.2 + 1/0.0049 + 1/0.0049); % [mol/L-min]
    rdp = rdp * 60; % [mol/L-h]
    if x < 272.5 / 6.02e23 % mass of one molecule of taxadiene
        rxd = 0;
    end
    if x < 60 / 6.02e23 % mass of one molecule of acetate
        rxa = 0;
    end
    if d < 853.9 / 6.02e23 % mass of one molecule of paclitaxel
        rdp = 0;
    end
    ras = 0;
    % integrate dxdt = F1 * C1 - (rxe + rxd + rxa) * Wx * Vs1; % [g/h]
    x = x + F1 * C1 * delt - (rxe + rxd + rxa) * Wx * Vs1 * delt; % [g]
    if x < 0
        x = 0;
```

```
end
% integrate dddt = rxd * Wx * Vs1 - rdp * Wd * Vs2; % [g/h]
d = d + rxd * Wx * Vs1 * delt - rdp * Wd * Vs2 * delt; % [g]
if d < 0
    d = 0;
end
% integrate dadt = rxa * Wx * Vs1 - ras * Wa * Vs2; % [g/h]
a = a + rxa * Wx * Vs1 * delt - ras * Wa * Vs2 * delt; % [g]
if a < 0
    a = 0;
end
% integrate dedt = rxe * Wx * Vs1; % [g/h]
e = e + rxe * Wx * Vs1 * delt; % [g]
if e < 0
    e = 0;
end
% integrate dsdt = ras * Wa * Vs2; % [g/h]
s = s + ras * Wa * Vs2 * delt;
if s < 0
    s = 0;
end
C2 = p / V; % [g/L]
% integrate dpdt = rdp * Vs2 - F2 * C2
p = p + rdp * Vs2 * Wd * delt - F2 * C2 * delt; % [g]
if p < 0
    p = 0;
end

% integrate dmdt = F1 * C1 - F2 * C2; % [g/h]
m = m + F1 * C1 * delt - F2 * C2 * delt; % [g]
if m < 0
    m = 0;
end
% integrate dms1dt = F1 * C1 - Vs1 * Wx * (rxd + rxa); % [g/h]
ms1 = ms1 + F1 * C1 * delt - Vs1 * Wx * (rxd + rxa) * delt; % [g]
if ms1 < 0
    ms1 = 0;
end
% integrate dms2dt = Vs1 * Wx * (rxd + rxa) - F2 * C2; % [g/h]
ms2 = ms2 + Vs1 * Wx * (rxd + rxa) * delt - F2 * C2 * delt; % [g]
if ms2 < 0
    ms2 = 0;
end

% Assuming Subsystems Maintain a constant temperature
% dhs1dt = Vs1 * (Hxd * Wd * rxd + Hxa * Wa * rxa + Hxe * We * rxe) - F6
F6 = Vs1 * Wx * (Hxd * rxd + Hxa * rxa + Hxe * rxe);
if F6 < 0
    F6 = 0;
end
% dhs2dt = Vs2 * (Hdp * Wp * rdp + Has * Ws * ras) - F7
F7 = Vs2 * (Hdp * Wd * rdp + Has * Wa * ras);
if F7 < 0
    F7 = 0;
end

% Assume F3 = 0
F3 = 0; % [J/h]
```

```
    dhdt = F6 + F7 - F3;
    if dhdt < 0
        dhdt = 0;
    end
    T = T + dhdt / (e + s + (rho_water - (e + s)) * V * cp); % [K]
end

plot(time, p_t)
title('Paclitaxel Mass in Reactor over Time')
xlabel('Time [hours]')
xlim([0,24])
ylabel('Paclitaxel Mass [g]')
```



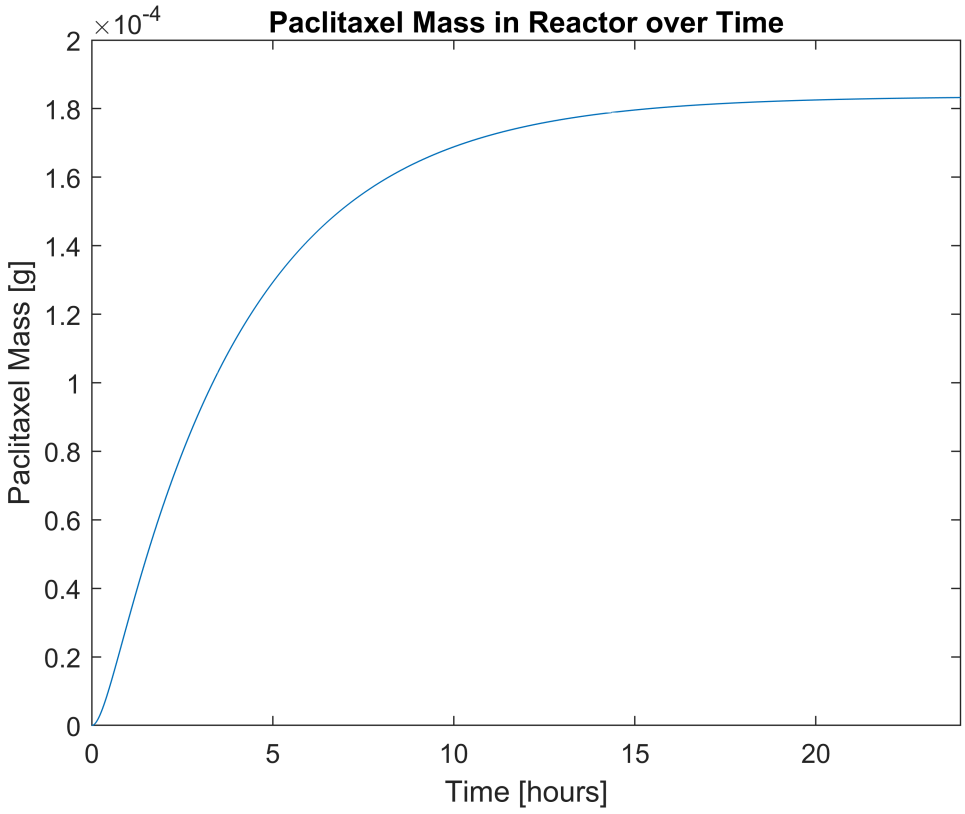
Iteration III

```
clear;
% Constants and Initial Conditions
F1 = 0; % [L/h]
C1 = 5; % [g/L]
F2 = 0; % [L/h]
V = 1; % [L]
T = 273 + 30; % [K]
cp = 4.186; % [J/g-K]

e = 2; % [g/L]
s = 2; % [g/L]
rho_cell = 200; % [g/L]
Vs1 = e * V / rho_cell; % [L]
Vs2 = s * V / rho_cell; % [L]
```

```
rho_water = 1000; % g/L

x = 5; % [g/L]
p = 0; % [g/L]
d = 0; % [g/L]
a = 0; % [g/L]

Wx = 150.13; % [g/mol]
Wd = 272.476; % [g/mol]
Wa = 60.052; % [g/mol]
Wp = 853.906; % [g/mol]

Hxd = 15; % [J/mol]
Hxa = 7; % [J/mol]
Hxe = 0; % [J/mol]
Hdp = 8; % [J/mol]
Has = 0; % [J/mol]

m = (e + s + x + p + d + a) * V; % [g]
ms1 = e; % [g]
ms2 = s; % [g]



time = 0:0.01:24; % [h]
p_t = zeros(length(time),1);
i = 1;
delt = 0.01;

for i = 1:length(time)
    p_t(i) = p; % [g]
    rxe = 0 * x;
    rxd = x * 1 / (1/0.65 + 1/0.57 + 1/0.891 + 1/0.078 + 1/0.52 + 1/0.134 + 1/0.0003 + 1/506 + 1/2 ...
        + 1/0.0035 + 1/0.06 + 1/0.06 + 1/0.00000133 + 1/0.109 + 1/3 + 1/1.6 + 1/23 + 1/33 + 1/0.75 ...
        + 1/0.099 + 1/0.03); % [mol/L-min]
    rxd = rxd * 60; % [mol/L-h]
    rxa = x * 1 / (1/0.65 + 1/0.57 + 1/0.891 + 1/0.078 + 1/0.52 + 1/0.134 + 1/0.885); % [mol/L-min]
    rxa = rxa * 60; % [mol/L-h]
    rdp = d * 1 / (1/0.016 + 1/5.77 + 1/0.00635 + 1/6.1 + 1/2.2 + 1/0.0049 + 1/0.0049); % [mol/L-min]
    rdp = rdp * 60; % [mol/L-h]
    if x < 272.5 / 6.02e23 % mass of one molecule of taxadiene
        rxd = 0;
    end
    if x < 60 / 6.02e23 % mass of one molecule of acetate
        rxa = 0;
    end
    if d < 853.9 / 6.02e23 % mass of one molecule of paclitaxel
        rdp = 0;
    end
    ras = 0 * a;
    % integrate dxdt = F1 * C1 - (rxe + rxd + rxa) * Wx * Vs1; % [g/h]
    x = x + F1 * C1 * delt - (rxe + rxd + rxa) * Wx * Vs1 * delt; % [g]
    if x < 0
        x = 0;
    end
    % integrate dddt = rxd * Wx * Vs1 - rdp * Wd * Vs2; % [g/h]
    d = d + rxd * Wx * Vs1 * delt - rdp * Wd * Vs2 * delt; % [g]
    if d < 0
```

```
    d = 0;
end
% integrate dadt = rxa * Wx * Vs1 - ras * Wa * Vs2; % [g/h]
a = a + rxa * Wx * Vs1 * delt - ras * Wa * Vs2 * delt; % [g]
if a < 0
    a = 0;
end
% integrate dedt = rxe * Wx * Vs1; % [g/h]
e = e + rxe * Wx * Vs1 * delt; % [g]
if e < 0
    e = 0;
end
% integrate dsdt = ras * Wa * Vs2; % [g/h]
s = s + ras * Wa * Vs2 * delt;
if s < 0
    s = 0;
end
C2 = p / V; % [g/L]
% integrate dpdt = rdp * Vs2 - F2 * C2
p = p + rdp * Vs2 * Wd * delt - F2 * C2 * delt; % [g]
if p < 0
    p = 0;
end

% integrate dmdt = F1 * C1 - F2 * C2; % [g/h]
m = m + F1 * C1 * delt - F2 * C2 * delt; % [g]
if m < 0
    m = 0;
end
% integrate dms1dt = F1 * C1 - Vs1 * Wx * (rxd + rxa); % [g/h]
ms1 = ms1 + F1 * C1 * delt - Vs1 * Wx * (rxd + rxa) * delt; % [g]
if ms1 < 0
    ms1 = 0;
end
% integrate dms2dt = Vs1 * Wx * (rxd + rxa) - F2 * C2; % [g/h]
ms2 = ms2 + Vs1 * Wx * (rxd + rxa) * delt - F2 * C2 * delt; % [g]
if ms2 < 0
    ms2 = 0;
end

% Assuming Subsystems Maintain a constant temperature
% dhs1dt = Vs1 * (Hxd * Wd * rxd + Hxa * Wa * rxa + Hxe * We * rxe) - F6
F6 = Vs1 * Wx * (Hxd * rxd + Hxa * rxa + Hxe * rxe);
if F6 < 0
    F6 = 0;
end
% dhs2dt = Vs2 * (Hdp * Wp * rdp + Has * Ws * ras) - F7
F7 = Vs2 * (Hdp * Wd * rdp + Has * Wa * ras);
if F7 < 0
    F7 = 0;
end

% Assume F3 = 0
F3 = 0; % [J/h]
dhdt = F6 + F7 - F3;
if dhdt < 0
    dhdt = 0;
end
```

```
    T = T + dhdt / (e + s + (rho_water - (e + s)) * V * cp); % [K]
end

plot(time, p_t)
title('Paclitaxel Mass in Reactor over Time')
xlabel('Time [hours]')
xlim([0,24])
ylabel('Paclitaxel Mass [g]')
```



Iteration IV

```
clear;
% Constants and Initial Conditions
F1 = 0; % [L/h]
C1 = 5; % [g/L]
F2 = 0; % [L/h]
V = 1; % [L]
T = 273 + 30; % [K]
cp = 4.186; % [J/g-K]

e = 2; % [g/L]
s = 2; % [g/L]
rho_cell = 200; % [g/L]
Vs1 = e * V / rho_cell; % [L]
Vs2 = s * V / rho_cell; % [L]
rho_water = 1000; % g/L

x = 5; % [g/L]
p = 0; % [g/L]
```

```
d = 0; % [g/L]
a = 0; % [g/L]

Wx = 150.13; % [g/mol]
Wd = 272.476; % [g/mol]
Wa = 60.052; % [g/mol]
Wp = 853.906; % [g/mol]

Hxd = 15; % [J/mol]
Hxa = 7; % [J/mol]
Hxe = 0; % [J/mol]
Hdp = 8; % [J/mol]
Has = 0; % [J/mol]

m = (e + s + x + p + d + a) * V; % [g]
ms1 = e; % [g]
ms2 = s; % [g]



time = 0:0.01:24; % [h]
p_t = zeros(length(time),1);
i = 1;
delt = 0.01;

for i = 1:length(time)
    p_t(i) = p; % [g]
    rxe = 0 * x;
    rxd = x * 0.5 * 1 / (1/0.65 + 1/0.57 + 1/0.891 + 1/0.078 + 1/0.52 + 1/0.134 + 1/0.0003 + 1/506 + 1/2
        + 1/0.0035 + 1/0.06 + 1/0.06 + 1/0.00000133 + 1/0.109 + 1/3 + 1/1.6 + 1/23 + 1/33 + 1/0.75 + ...
        1/0.099 + 1/0.03); % [mol/L-min]
    rxd = rxd * 60; % [mol/L-h]
    rxa = x * 0.5 * 1 / (1/0.65 + 1/0.57 + 1/0.891 + 1/0.078 + 1/0.52 + 1/0.134 + 1/0.885); % [mol/L-mir
    rxa = rxa * 60; % [mol/L-h]
    rdp = d *1 / (1/0.016 + 1/5.77 + 1/0.00635 + 1/6.1 + 1/2.2 + 1/0.0049 + 1/0.0049); % [mol/L-min]
    rdp = rdp * 60; % [mol/L-h]
    if x < 272.5 / 6.02e23 % mass of one molecule of taxadiene
        rxd = 0;
    end
    if x < 60 / 6.02e23 % mass of one molecule of acetate
        rxa = 0 * a;
    end
    if d < 853.9 / 6.02e23 % mass of one molecule of paclitaxel
        rdp = 0;
    end
    ras = 0 * a;
    % integrate dxdt = F1 * C1 - (rxe + rxd + rxa) * Wx * Vs1; % [g/h]
    x = x + F1 * C1 * delt - (rxe + rxd + rxa) * Wx * Vs1 * delt; % [g]
    if x < 0
        x = 0;
    end
    % integrate dddt = rxd * Wx * Vs1 - rdp * Wd * Vs2; % [g/h]
    d = d + rxd * Wx * Vs1 * delt - rdp * Wd * Vs2 * delt; % [g]
    if d < 0
        d = 0;
    end
    % integrate dadt = rxa * Wx * Vs1 - ras * Wa * Vs2; % [g/h]
    a = a + rxa * Wx * Vs1 * delt - ras * Wa * Vs2 * delt; % [g]
```

```
    if a < 0
        a = 0;
    end
    % integrate dedt = rxe * Wx * Vs1; % [g/h]
    e = e + rxe * Wx * Vs1 * delt; % [g]
    if e < 0
        e = 0;
    end
    % integrate dsdt = ras * Wa * Vs2; % [g/h]
    s = s + ras * Wa * Vs2 * delt;
    if s < 0
        s = 0;
    end
    C2 = p / V; % [g/L]
    % integrate dpdt = rdp * Vs2 - F2 * C2
    p = p + rdp * Vs2 * Wd * delt - F2 * C2 * delt; % [g]
    if p < 0
        p = 0;
    end

    % integrate dmdt = F1 * C1 - F2 * C2; % [g/h]
    m = m + F1 * C1 * delt - F2 * C2 * delt; % [g]
    if m < 0
        m = 0;
    end
    % integrate dms1dt = F1 * C1 - Vs1 * Wx * (rxd + rxa); % [g/h]
    ms1 = ms1 + F1 * C1 * delt - Vs1 * Wx * (rxd + rxa) * delt; % [g]
    if ms1 < 0
        ms1 = 0;
    end
    % integrate dms2dt = Vs1 * Wx * (rxd + rxa) - F2 * C2; % [g/h]
    ms2 = ms2 + Vs1 * Wx * (rxd + rxa) * delt - F2 * C2 * delt; % [g]
    if ms2 < 0
        ms2 = 0;
    end

    % Assuming Subsystems Maintain a constant temperature
    % dhs1dt = Vs1 * (Hxd * Wd * rxd + Hxa * Wa * rxa + Hxe * We * rxe) - F6
    F6 = Vs1 * Wx * (Hxd * rxd + Hxa * rxa + Hxe * rxe);
    if F6 < 0
        F6 = 0;
    end
    % dhs2dt = Vs2 * (Hdp * Wp * rdp + Has * Ws * ras) - F7
    F7 = Vs2 * (Hdp * Wd * rdp + Has * Wa * ras);
    if F7 < 0
        F7 = 0;
    end

    % Assume F3 = 0
    F3 = 0; % [J/h]
    dhdt = F6 + F7 - F3;
    if dhdt < 0
        dhdt = 0;
    end
    T = T + dhdt / (e + s + (rho_water - (e + s)) * V * cp); % [K]
end

plot(time, p_t)
```

```
title('Paclitaxel Mass in Reactor over Time')
xlabel('Time [hours]')
xlim([0,24])
ylabel('Paclitaxel Mass [g]')
```