Scilab Textbook Companion for Elements Of Chemical Reaction Engineering by H. S. Fogler[1]

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Book Description

Title: Elements Of Chemical Reaction Engineering

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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

Contents

List of Scilab Codes

Chapter 1

Mole Balances

Scilab code Exa 1.3 Find V

```
1  //clear//
2  clc
3  clear
4  exec("1.3data.sci");
5
6  //CA = 0.1*CA0;
7  V = (v0/k)*log(1/0.1);
8  disp("V =")
9  disp(V)
10 disp ("dm^3")
```

Chapter 2

Conversion and Reactor Sizing

Scilab code Exa 2.1 calculate mole

```
1 //clear//
2 clc
3 clear
4 exec("2.1data.sci");
5 CA0=(yA0*P0)/(R*T0);
6 FA0 = CA0*v0;
7 disp("CA0 =")
8 disp(CA0)
9 disp ("mol/dm^3")
10 disp("FA0 =")
11 disp(FA0)
12 disp("mol/s")
```

Scilab code Exa 2.2 Volume

```
1 //clear//
2 clc
3 clear
```

```
4  exec("2.2data.sci");
5  CA0=(yA0*P0)/(R*T0);
6  FA0 = CA0*v0;
7  V = FA0*X*(1/-rA)
8
9  disp("FA0 =")
10 disp(FA0)
11 disp("mol/s")
12 disp("V =")
13 disp(V)
14 disp ("dm^3")
```

Scilab code Exa 2.3 Volume

```
1  //clear//
2  clc
3  clear
4  exec("2.3data.sci");
5  CA0=(yA0*P0)/(R*T0);
6  FA0 = CA0*v0;
7  //V = FA0*X*(1/-rA)
8
9  V = FA0*inttrap(X,p)
10 disp("FA0 =")
11 disp(FA0)
12 disp("mol/s")
13 disp("V =")
14 disp(V)
15 disp ("dm^3")
16 disp("Answer is slightly differennt from the book
   because inttrap command of SCILAB uses
   trapezoidal integration, while in book it has
   been calculated using five point formulae.")
```

Scilab code Exa 2.4 clear

```
1  //clear//
2  clc
3  clear
4  exec("2.4data.sci");
5
6
7  VCSTR = FA0*X(7)*(1/-rAat);
8  VPFR = FA0*inttrap(X,p)
9  disp("VCSTR =")
10 disp(VCSTR)
11 disp("dm^3")
12 disp("VPFR =")
13 disp(VPFR)
14 disp ("dm^3")
```

Scilab code Exa 2.5 clear

```
1  //clear//
2  clc
3  clear
4  exec("2.5data.sci");
5
6
7  V1 = FA0*X1*(1/-rA);
8  V2 = FA0*(X2-X1)*(1/-rA2);
9  V = FA0*X*(1/-rA2);
10 disp("V1 =")
11 disp(V1)
12 disp("dm^3")
13 disp("V2 =")
```

```
14 disp(V2)
15 disp ("dm^3")
16 disp("V =")
17 disp(V)
18 disp ("dm^3")
```

Scilab code Exa 2.6 clear

```
1  //clear//
2  clc
3  clear all
4  exec("2.6data.sci");
5
6
7  X1 = X(1:5);
8  p1 = p(1:5);
9  V1 = FA0*inttrap(X1,p1)
10 X2 = X(5:9);
11 p2 = p(5:9);
12 V2 = FA0*inttrap(X2,p2)
13 V=V1+V2;
14 disp("V1 =")
15 disp(V1)
16 disp("dm^3")
17 disp("V2 =")
18 disp(V2)
19 disp ("dm^3")
20 disp("V =")
21 disp(V)
22 disp ("dm^3")
```

Scilab code Exa 2.7 clear

```
1  //clear//
2  clc
3  clear
4  exec("2.7data.sci");
5
6
7  X = X(1:6);
8  p = p(1:6);
9  V1 = FA0*inttrap(X,p);
10 V2 = FA0*(X2-X1)*(1/-rA2);
11 V=V1+V2;
12 disp("V1 =")
13 disp(V1)
14 disp("dm^3")
15 disp("V2 =")
16 disp(V2)
17 disp ("dm^3")
18 disp("V =")
19 disp(V)
20 disp ("dm^3")
```

Chapter 3

Rate Laws and Stoichiometry

Scilab code Exa 3.5 clear

```
1  //clear//
2  clc
3  clear
4  exec("3.5data.sci");
5  CD=CA0*(X/3);
6  CB=CA0*((CB0/CA0)-(X/3));
7  CD1=CA0*(X1/3);
8  CB1=CA0*((CB0/CA0)-(X1/3));
9  disp("For 20% conversion")
10 disp("CD =")
11 disp(CD)
12 disp ("mol/dm^3")
13 disp("CB =")
14 disp(CB)
15 disp("mol/dm^3")
16 disp("For 90% conversion")
17 disp("CD =")
18 disp(CD1)
19 disp ("mol/dm^3")
20 disp("CB =")
21 disp(CB1)
```

```
22 disp("mol/dm^3")
```

Chapter 4

Isothermal Reactor Design

Scilab code Exa 4.1 clear

```
1  //clear//
2  clc
3  clear
4  exec("4.1data.sci");
5
6  x=t;
7  y =((CA0-CC)/CA0);
8
9  yi=interpln([x;y],x);
10 plot2d(x,y,logflag='nl');
11
12 k = log(y(9)/y(2))/(t(9)-t(2));
13
14
15 disp("k =")
16 disp(k)
17 disp ("min^-1")
```

Scilab code Exa 4.2 clear

```
//clear//
clc
clear
exec("4.2data.sci");

 FA0 = FC/X;
 vA0 = FA0/CA01;
 vB0 = vA0;
 v0 = vA0+vB0;
 V = v0*X/(k*(1-X));

 // CSTR in parallel
 V1 = 800/7.48;

 Tau =V1/(v0/2);
 Da= Tau*k;
 Xparallel = Da/(1+Da)

 // CSTR in series
 Tau =V1/v0;
 n=2;
 Xseries = 1- (1/(1+Tau*k)^n);

disp("Reactor volume")
disp(V)
disp ("ft^3")
disp("CSTR in parallel X =")
disp(Xparallel)
disp("CSTR in series X =")
disp(Xseries)
```

Scilab code Exa 4.4 clear

```
//clear//
clc
```

```
clear
exec("4.4data.sci");

 FA0 = FB/X;
 CA0 = yA0*P0/(R*T0);
 R = 1.987;
 k2 = k1*exp((E/R)*((1/T1)-(1/T2)));
 V =( FA0/(k2*CA0))*((1+e)*log(1/(1-X))-e*X);

disp("Reactor volume")
disp(V)
disp("ft^3")
```

Scilab code Exa 4.5 clear

```
//clear//
clc
clear
exec("4.5data.sci");

G = m/Ac;
bita0 = (G*(1-phi)/(gc*rho*Dp*phi^3))*((150*(1-phi)*
   mu/Dp)+1.75*G);
bita0 = bita0/(144*14.7);//atm/ft
P = ((1-(2*bita0*L/P0))^.5)*P0;
deltaP = P0 - P;

disp("deltaP")
disp(deltaP)
disp("atm")
```

Scilab code Exa 4.6 clear

```
1  //clear//
2  clc
3  clear
4  exec("4.6data.sci");
5
6  FT0 = FA0+FB0+FI;
7  yA0 = FA0/FT0;
8  e = yA0*(1-.5-1);
9  PA0 = yA0*P0;
10 kdes = k*PA0*(1/2)^(2/3);
11 alpha = 2*bita0/(Ac*(1-phi)*rhoc*P0);
12 W = (1 - (1-(3*alpha*FA0/(2*kdes))*((1+e)*log(1/(1-X
      ))-e*X))^(2/3))/alpha;
13
14
15 disp("W")
16 disp(W)
17 disp("lb of catalyst per tube")
```

Scilab code Exa 4.7 clear

```
1  //clear//
2  clc
3  clear
4  exec("4.7data.sci");
5   W = 0:1:60;
6  function w=f(W,Y)
7
8  w=zeros(2,1);
9  w(1)= (kprime/FA0)*((1-Y(1))/(1+e*Y(1)))*Y(2);
10 w(2) = -alpha*(1+e*Y(1))/(2*Y(2));
11 endfunction
12
13
14 x=ode([0;1],W0,W,f);
```

```
15 for i= 1:61
16   F(i) = (1+e*x(1,i))/x(2,i);
17 end
18 F= F';
19 for i= 1:61
20   rate(i) = (kprime)*((1-x(1,i))/(1+e*x(1,i)))*x(2,i
       );
21 end
22 rate =rate';
23
24 scf(1)
25 plot2d(W,rate);
26 xtitle( 'Figure E4-7.1 Reaction rate porfile down
     the PBR', 'w', 'rate' ) ;
27 scf(2)
28
29 l1=x(1,: )'
30 l2=x(2,: )'
31 l3=F'
32 plot2d(W',[l1 l2 l3]);
33
34 xtitle( 'Figure E4-7.2', 'w', 'x,y,z' ) ;
35 legend(['x';'y';'f']);
```

Scilab code Exa 4.8 clear

```
1 //clear//
2 clc
3 clear
4 exec("4.8data.sci");
5 Z = 0:1:12;
6 function w=f(Z,Y)
7
8  w=zeros(2,1);
9  Ac= 3.14*((R^2)-(Z-L)^2);
```

```
10   Ca = Ca0*(1-Y(1))*Y(2)/(1+Y(1));
11   ra =kprime*Ca*rhocat*(1-phi);
12   G= m/Ac;
13   V =3.14*(Z*(R^2)-(1.3*(Z-L)^3)-(1/3)*L^3)
14   bita = (98.87*G+25630*G^2)*0.01;
15   W=rhocat*(1-phi)*V
16 w(1)= -ra*Ac/FA0
17 w(2) = -bita/P0/(Y(2)*(1+Y(1)));
18 endfunction
19
20
21 x=ode([0;1],Z0,Z,f);
22 for i= 1:length(Z)
23   V(1,i) =3.14*Z(1,i)*((R^2)-(Z(1,i)-L)^2)
24    W1(1,i)=rhocat*(1-phi)*V(1,i)
25 end
26
27 l1=x(1,:)'
28 l2=x(2,:)'
29
30 plot2d(W1',[l1 l2]);
31
32 xtitle( 'Figure E4-8.2', 'w', 'x,y' ) ;
33 legend(['x';'y']);
```

Scilab code Exa 4.9 clear

```
1 //clear//
2 clc
3 clear
4 exec("4.9data.sci");
5  V = 0:1:100;
6 function w=f(V,fa)
7
8  w=zeros(1,1);
```

```
 ft =2*(fa0-fa(1))
 Ca = Ct0*fa(1)/ft;
 fb = 2*(fa0-fa(1));
 Cb = Ct0*fb/ft;
w(1)= -ka*(Ca-(Cb^2)/kc)

endfunction


x=ode([9.99],V0,V,f);

for i= 1:101
   fb(1,i) = 2*(fa0-x(1,i));
end
l1=x';
l2=fb';

plot2d(V',[l1 l2]);

xtitle( 'Figure E4-9.1 Molar flow rate profiles', 'V
   ', 'fa,fb' ) ;
legend(['fa';'fb']);
```

Scilab code Exa 4.10 clear

```
//clear//
clc
clear
exec("4.10data.sci");
 V = 0:1:500;
function w=f(V,F)

 w=zeros(3,1);

 Ft=F(1)+F(2)+F(3);
```

```
11   ra = -k*Ct0*((F(1)/Ft)-(Ct0/kc)*(F(2)/Ft)*(F(3)/Ft)
       );
12   w(1)= ra;
13   w(2) = -ra-kc*Ct0*(F(2)/Ft)
14   w(3) = -ra;
15
16 endfunction
17
18
19 x=ode([10;0;0],V0,V,f);
20
21 l1=x(1,:)'
22 l2=x(2,:)'
23 l3=x(3,:)'
24 plot2d(V',[l1 l2 l3]);
25
26 xtitle( 'Figure E4-10.2', 'V', 'Fa,Fb,Fc' ) ;
27 legend(['Fa';'Fb';'Fc']);
```

Scilab code Exa 4.11 clear

```
1  //clear//
2  clc
3  clear
4  exec("4.11data.sci");
5   t = 0:1:500;
6  function w=f(t,C)
7
8   w =zeros(4,1);
9
10  v = v0+v00*t;
11  w(1)= -k*C(1)*C(2)-v00*C(1)/v;
12  w(2) = -k*C(1)*C(2)+v00*(Cb0-C(2))/v;
13  w(3) = k*C(1)*C(2)-v00*C(3)/v;
14  w(4) = k*C(1)*C(2)-v00*C(4)/v;
```

```
15
16 endfunction
17
18
19 x=ode([.049;0;0;0],t0,t,f);
20 l1=x(1,: )'
21 l2=x(2,: )'
22 l3=x(3,: )'
23 for i = 1:length(t)
24   rate(1,i)=k*x(1,i )*x(2,i)
25   end
26 scf(1)
27 plot2d(t',[l1 l2 l3]);
28
29 xtitle( 'Figure E4-11.1 Concentration-time
      trajectories', 't', 'Ca,Cb,Cc' ) ;
30 legend(['Ca';'Cb';'Cc']);
31 scf(2)
32 plot2d(t,rate)
33 xtitle( 'Figure E4-11.2 Reaction rate-time
      trajectories', 't', 'Reaction Rate(mols dm^3)' )
      ;
34
35
36
37
38 'V
```

Chapter 5

Collection and Analysis of Rate Data

Scilab code Exa 5.1 clear

```
1 //clear//
2 p = [ 1.44  .95  .74]';
3 dt = 2.5
4 t = [0  2.5  5]';
5 dp(1) =( 3*p(1)+4p(2)-p(3))/(2*dt);
6 for i=2:n1
7  dp p(i+3
```

Scilab code Exa 5.2 Clear

```
1 //clear//
2 clc
3 clear
4 exec("5.2data.sci");
5  for i =1:length(t)
6 g(i) =log(2*P0/(3*P0-P(i)));
```

```
7  end
8  plot2d(t,g);
9
10 xtitle( 'Figure E4-11.2 Plot of processed data', 't
      (min)', '2PTo/3PTo-PT' ) ;
```

Scilab code Exa 5.3 Clear

```
1  //Clear//
2  clc
3  clear
4  exec("5.3data.sci");
5
6  x=log(CHCl);
7  y=log(-rHCl);
8  plot2d(x,y);
9
10 xtitle( 'Figure E5-3.2 ', 'CHCl (g mol/ liter)', '
      rHCl0 (g mol / cm^2.s)' ) ;
```

Scilab code Exa 5.4 Clear

```
1  //Clear//
2  clc
3  clear
4  exec("5.4data.sci");
5
6  rCH4 = (v0/W)*CCH4;x
7  x=log(PCO);
8  y = log(rCH4)
9  alpha= (y(3)-y(2))/(x(3)-x(2));
10 //plot2d(x,y)
11 disp("alpha")
```

```
12 disp(alpha)
```

Chapter 6

Multiple Reactions

Scilab code Exa 6.6 Clear

```
1  //Clear//
2  clc
3  clear
4  exec("6.6data.sci");
5   t = 0:.01:.5;
6  function w=f(t,c)
7
8   w =zeros(3,1);
9
10 r1 = -k1*c(2)*c(1)^.5;
11 r2 = -k2*c(3)*c(1)^.5;
12  w(1)= r1+r2;
13  w(2) = r1;
14  w(3) = -r1+r2;
15
16 endfunction
17
18 x=ode([.021;.0105;0],t0,t,f);
19
20 l1=x(1,: )'
21 l2=x(2,: )'
```

```
22 l3=x(3,: )'
23
24 plot2d(t',[l1 l2 l3]);
25
26 xtitle( 'Figure E6-6.1', 'Tau (hr)', 'Concentration
     (lb mol/ft^3' ) ;
27 legend(['CH';'CM';'CX']);
```

Scilab code Exa 6.8 clear

```
1  //clear//
2  clc
3  clear
4  exec("6.8data.sci");
5   v = 0:.1:10;
6  function w =FF(v,f)
7
8   w =zeros(6,1);
9   ft = f(1)+f(2)+f(2)+f(4)+f(5)+f(6);
10  r1a = -5*8*(f(1)/ft)*(f(2)/ft)^2;
11  r2a = -2*4*(f(1)/ft)*(f(2)/ft);
12  r4c = -5*3.175*(f(3)/ft)*(f(1)/ft)^(2/3);
13  r3b = -10*8*((f(3)/ft)^2)*(f(2)/ft);
14  Ca =2*f(1)/ft;
15  Cb =2*f(2)/ft;
16  Cc =2*f(3)/ft;
17  Cd =2*f(4)/ft;
18  Ce =2*f(5)/ft;
19  Cf =2*f(6)/ft;
20 w(1)= 1.25*r1a+.75*r2a+r3b;
21  w(2) = r1a+r2a+2*r4c/3;
22  w(3) = -r1a+2*r3b+r4c;
23  w(4) =-1.5*r1a-1.5*r2a-r4c;
24  w(5) =.5*r2a-5*r4c/6;
25  w(6) = -2*r3b;
```

```
26
27 endfunction
28
29 x=ode([9;9;0;0;0;0],v0,v,FF);
30
31 plot2d(v,x(1,:)/10,rect=[1,0,10,1.5]); //B
32 plot2d(v,x(2,:)/10,rect=[1,0,10,1.5]); //A
33 plot2d(v,x(3,:)/10,rect=[1,0,10,1.5]); //C
34 plot2d(v,x(4,:)/10,rect=[1,0,10,1.5]);
35 plot2d(v,x(5,:)/10,rect=[1,0,10,1.5]);
36 plot2d(v,x(6,:)/10,rect=[1,0,10,1.5]);
37 xtitle('FigureE');
38 legend (['B';'A';'C';'D';'E';'F']);
```

Chapter 7

Nonelementary Reaction Kinetics

Scilab code Exa 7.7 clear

```
1  //clear//
2  clc
3  clear
4  exec("7.7data.sci");
5  for i=1:length(Curea)
6  x(i)= 1/Curea(i);
7  y(i) = 1/(-rurea(i));
8  end
9   slope = (y(5)-y(1))/(x(5)-x(1));
10  plot2d(x,y)
11
12  xtitle( 'Figure E7-7.1', '1/Curea', '1/-rurea' ) ;
13
14  disp("(Km/Vma = slope")
15  disp(slope)
```

Scilab code Exa 7.8 clear

```
1 //clear//
2 clc
3 clear
4 exec("7.8data.sci");
5 Vmax = (Et2/Et1)*Vmax1
6 t = (Km/Vmax)*log(1/(1-X))+Curea0*X/Vmax;
7 disp("t")
8 disp(t)
9 disp("s")
```

Scilab code Exa 7.9 clear

```
1 //clear//
2 clc
3 clear
4 exec("7.9data.sci");
5  t = 0:.1:12;
6 function w=f(t,c)
7
8  w =zeros(3,1);
9
10 rd = c(1)*.01;
11 rsm = m/c(1);
12 kobs= (umax*(1-c(3)/93)^.52);
13 rg= kobs*c(1)*c(2)/(ks+c(2));
14 //r2 = -k2*c(3)*c(1)^.5;
15  w(1)= rg-rd;
16  w(2) = ysc*(-rg)-rsm;
17  w(3) = rg*ypc;
18
19 endfunction
20
21 x=ode([1;250;0],t0,t,f);
```

```
22
23 l1=x(1,: )'
24 l2=x(2,: )'
25 l3=x(3,: )'
26
27 plot2d(t',[l1 l2 l3]);
28
29 xtitle( 'Figure E7-9.1 concentrations as a function
      of time', 't (hr)', 'C (g/dm^3)' ) ;
30 legend(['Cc';'Cs';'Cp']);
```

Chapter 8

Steady State Nonisothermal Reactor Design

Scilab code Exa 8.3 clear

```
1 //clear//
2 clc
3 clear
4 exec("8.3data.sci");
5 deltaHRx0 = 2*H0NH3-3*H0H2-HN2;
6 deltaCp = 2*CpNH3-3*CpH2-CpN2;
7 deltaHRx = deltaHRx0+deltaCp*(T-TR);
8 disp("The heat of reaction on the basis on the moles
      of H2 reacted is =")
9 disp((1/3)*deltaHRx*4.184)
10 disp("J at 423 K")
```

Scilab code Exa 8.4 clear

```
1 //clear//
2 clc
```

```
clear
exec("8.4data.sci");
HRx0 = H0C-H0B-H0A;
deltaCp = CpC-CpB-CpA;
deltaHRx0 = HRx0+deltaCp*(TR-TR);
v0 = vA0+vB0+VM0;
tau = V/v0;
CA0 = FA0/v0;
phiM0 = FM0/FA0;
phiB0 = FB0/FA0;
Cpi = CpA+phiB0*CpB+phiM0*CpM;

for i =1:length(T)
XEB(i) = -Cpi*(T(i)-Ti0)/(deltaHRx0+deltaCp*(T(i)-TR
   ));
XMB(i) = tau*A*exp(-E/(R*T(i)))/(1+tau*A*exp(-E/(R*T
   (i))));
end



plot2d(T',[XEB XMB]);

xtitle( 'Figure E8-4.2', 'T(oR)', 'Conversion, X' )
   ;
legend(['XEB';'XMB']);
```

Scilab code Exa 8.6 clear

```
//clear//
clc
clear
exec("8.6data.sci");
 V = 0:.1:3.6;
function w=f(V,X)
```

```
7
8   w =zeros(1,1);
9  T =330+43.3*X;
10 k=31.1*exp(7906*(T-360)/(T*360));
11 Kc = 3.03*exp(-830.3*((T-360)/(T*360)));
12 Xe = Kc/(1+Kc);
13 ra = -k*Ca0*(1-(1+(1/Kc))*X);
14  w(1)= -ra/Fa0;
15  rate = -ra;
16 endfunction
17
18 x=ode([0],V0,V,f);
19
20 for i =1:length(x)
21   T(1,i) =330+43.3*x(1,i)
22
23   k(1,i)=31.1*exp(7906*(T(1,i)-360)/(T(1,i)*360));
24   Kc(1,i) = 3.03*exp(-830.3*((T(1,i)-360)/(T(1,i)
       *360)));
25
26   ra(1,i) = k(1,i)*Ca0*(1-(1+(1/Kc(1,i)))*x(1,i));
27 end
28 scf(1)
29 plot2d(V,x(1,:));
30
31 xtitle( 'Figure E8-6.1a', 'V(m^3)', 'X' ) ;
32 scf(2)
33 plot2d(V,T(1,:));
34
35 xtitle( 'Figure E8-6.1b', 'V(m^3)', 'T (K)' ) ;
36
37 scf(3)
38 plot2d(V,ra);
39
40 xtitle( 'Figure E8-6.1c', 'V(m^3)', '-ra (kmol/m^3hr
     )' ) ;
```

Scilab code Exa 8.7 clear

```
1  //clear//
2  clc
3  clear
4  //this code is only for the first part of the
       problem (Adiabatic PFR)
5  exec("8.7data.sci");
6   V = 0:.1:5;
7  function w=f(V,Y)
8
9   w =zeros(2,1);
10
11 k=(8.2e14)*exp(-34222/Y(1));
12
13 Cpa = 26.63+.183*Y(1)-(45.86e-6)*(Y(1)^2);
14 delCp = 6.8-(11.5e-3)*Y(1)-(3.81e-6)*(Y(1)^2);
15 deltaH = 80770+6.8*(Y(1)-Tr)-(5.75e-3)*((Y(1)^2)-Tr
       ^2)-(1.27e-6)*((Y(1)^3)-Tr^3);
16 ra = -k*Ca0*(((1-Y(2))/(1+Y(2)))*(T0/Y(1)));
17 w(1) = -ra*(-deltaH)/(Fa0*(Cpa+Y(2)*delCp));
18 w(2)= -ra/Fa0;
19
20 endfunction
21
22 x=ode([1035;0],V0,V,f);
23 scf(1)
24 plot2d(V,x(1,:));
25
26 xtitle( 'Figure E8-7.1', 'V (m^3)', 'T (K)' ) ;
27
28 scf(2)
29 plot2d(V,x(2,:));
30
```

```
31 xtitle( 'Figure E8-7.1', 'V (m^3)', 'X' ) ;
```

Scilab code Exa 8.8 clear

```
1 //clear//
2 clc
3 clear
4 exec("8.8data.sci");
5 for i = 1:length(T)
6   Xe(i) = 100000*exp(-33.78*(T(i)-298)/(T(i)))/(1+
      100000*exp(-33.78*(T(i)-298)/T(i)));
7   XEB(i) = (2.5e-3)*(T(i)-300);
8 end
9 plot2d(T,[Xe XEB])
10
11 xtitle( 'Figure E8-8.1', 'T', 'X' ) ;
12 legend(['Xe';'XEB']);
```

Scilab code Exa 8.9 clear

```
1 //clear//
2 clc
3 clear
4 //eY(2)ec("8.6data.sci");
5 W = 0:1:28.58;
6 W0=0;
7 function w=f(W,Y)
8   w =zeros(3,1);
9
10
11 fao=.188
12 visc=.090
13 Ta=1264.67
```

```
14 deltah=-42471-1.563*(Y(3)-1260)+.00136*(Y(3)
     **2-1260**2)-(2.459*10**(-7))*(Y(3)**3-1260**3);
15 summ= 57.23+.014 * Y(3)-1.94 *10**(-6.)*Y(3)**2
16 dcp=-1.5625+2.72*10**(-3)*Y(3)-7.38*10**(-7)*Y(3)**2
17 k=360D*exp(-176008/Y(3)-(110.1*log(Y(3)))+912.8)
18 thetaso=0;
19 Po=2
20 Pao=.22
21 thetao=.91
22 eps=-.055
23 R=1.987;
24 Kp=exp(42311/R/Y(3)-11.24);
25 if(Y(2)< =.05)
26
27   ra=(-k*(.848-.012/(Kp**2)));
28 else
29   ra=(-k*(1-Y(2))/(thetaso+Y(2)))**.5*(Y(1)/Po*Pao
       *((thetao-.5*Y(2))/((1+eps*Y(2)))-((thetaso+Y
       (2))/(1-Y(2)))**2/(Kp**2)));
30 end
31
32 w(1)=(-1.12*10**(-8)*(1-.055*Y(2))*Y(3))*(5500*visc
     +2288)/Y(1) ;
33 w(2)=-(ra)/fao ;
34 w(3)=(5.11*(Ta-Y(3))+(-ra)*(-deltah) )/(fao*(summ+Y
     (2)*dcp))
35 endfunction
36
37 X=ode([2;0;1400],W0,W,f);
38
39 plot2d(W,X(1,:));
40 plot2d(W,X(3,:));
```

Scilab code Exa 8.10 clear

```
1  //clear//
2  clc
3  clear
4  //eY(2)ec("8.6data.sci");
5  W = 0:1:28.58;
6  W0=0;
7  function w=f(W,Y)
8    w =zeros(3,1);
9
10
11 fao=.188
12 visc=.090
13 Ta=1264.67
14 deltah=-42471-1.563*(Y(3)-1260)+.00136*(Y(3)
      **2-1260**2)-(2.459*10**(-7))*(Y(3)**3-1260**3);
15 summ= 57.23+.014 * Y(3)-1.94 *10**(-6.)*Y(3)**2
16 dcp=-1.5625+2.72*10**(-3)*Y(3)-7.38*10**(-7)*Y(3)**2
17 k=360D*exp(-176008/Y(3)-(110.1*log(Y(3)))+912.8)
18 thetaso=0;
19 Po=2
20 Pao=.22
21 thetao=.91
22 eps=-.055
23 R=1.987;
24 Kp=exp(42311/R/Y(3)-11.24);
25 if(Y(2)< =.05)
26
27   ra=(-k*(.848-.012/(Kp**2)));
28 else
29   ra=(-k*(1-Y(2))/(thetaso+Y(2)))**.5*(Y(1)/Po*Pao
        *((thetao-.5*Y(2))/((1+eps*Y(2)))-((thetaso+Y
        (2))/(1-Y(2)))**2/(Kp**2)));
30 end
31
32 w(1)=(-1.12*10**(-8)*(1-.055*Y(2))*Y(3))*(5500*visc
      +2288)/Y(1) ;
33 w(2)=-(ra)/fao ;
34 w(3)=(5.11*(Ta-Y(3))+(-ra)*(-deltah) )/(fao*(summ+Y
```

```
   (2)*dcp))
endfunction

X=ode([2;0;1400],W0,W,f);

plot2d(W,X(1,:));
plot2d(W,X(3,:));
```

Scilab code Exa 8.11 clear

```
//clear//
clc
clear
exec("8.11data.sci");
V = 0:.01:1;

function w=f(V,Y)

 w =zeros(4,1);

k1a=10*exp(4000*((1/300)-(1/Y(4))));
k2a=.09*exp(9000*((1/300)-(1/Y(4))))

Ft=Y(1)+Y(2)+Y(3);

Ca=Cto*(Y(1)/Ft)*(To/Y(4))
Cb=Cto*(Y(2)/Ft)*(To/Y(4))
Cc=Cto*(Y(3)/Ft)*(To/Y(4))
r1a=-k1a*Ca;
r2a=-k2a*Ca^2;

w(1)=r1a+r2a;
w(2)=-r1a;

w(3)=-r2a/2;
```

```
26 w(4)=(4000*(373-Y(4))+(-r1a)*20000+(-r2a)*60000)
      /(90*Y(1)+90*Y(2)+180*Y(3));
27 endfunction
28
29 x=ode([100;0;0;423],V0,V,f);
30
31 scf(1)
32 plot2d(V,x(4,:));
33
34 xtitle( 'Figure E8-11.1', 'V', 'T' ) ;
35
36 scf(2)
37
38 l1=x(1,: )'
39 l2=x(2,: )'
40 l3=x(3,: )'
41 plot2d(V',[l1 l2 l3]);
42
43 xtitle( 'Figure E8-11.2', 'V', 'Fa,Fb,Fc' ) ;
44 legend(['Fa';'Fb';'Fc']);
```

Scilab code Exa 8.12 clear

```
1 //clear//
2 clc
3 clear
4 exec("8.12data.sci");
5 t=1:10:250;
6 for i=1:length(t)
7 T(i)=2*t(i)+283;
8
9 k2(i)=4.58*exp((E2/1.987)*((1/500)-(1/T(i))))
10 k1(i)=3.3*exp((E1/1.987)*((1/300)-(1/T(i))))
11 Ca(i)=Cao/(1+tau*k1(i))
12 kappa=UA/(vo*Cao)/Cp
```

```
13 G(i)=-(tau*k1(i)/(1+k1(i)*tau))*DH1-(k1(i)*tau*k2(i)
      *tau*DH2/((1+tau*k1(i)) *(1+tau*k2(i))));
14 Tc=(To+kappa*Ta)/(1+kappa);
15 Cb(i)=tau*k1(i)*Ca(i)/(1+k2(i)*tau);
16 R(i)=Cp*(1+kappa)*(T(i)-Tc);
17 Cc=Cao-Ca(i)-Cb(i);
18 F(i)=G(i)-R(i);
19 end
20 plot(T',[G R])
21
22 xtitle( 'Figure E8-12.1', 'T (K)', 'G(T),R(T)' ) ;
23 legend(['G(T)';'R(T)']);
```

Chapter 9

Unsteady State Nonisothermal Reactor Design

Scilab code Exa 9.1 clear

```
1  //clear//
2  clc
3  clear
4  exec("9.1data.sci");
5   t = 0:10:1500;
6  function w=f(t,x)
7
8   w =zeros(1,1);
9
10 t1=535+90.45*x
11 k= .000273*exp(16306*((1/535)-(1/t1)));
12 w(1)=k*(1-x)
13 endfunction
14
15 X=ode([0],t0,t,f);
16 T=535+90.45*X;
17 scf(1)
18 plot2d(t,T);
19
```

```
20 xtitle( 'Figure E9-1.1', 't (Seconds)', 'T (oR)' ) ;
21
22 scf(2)
23 plot2d(t,X);
24
25 xtitle( 'Figure E9-1.1', 't (Seconds)', 'X' ) ;
```

Scilab code Exa 9.2 clear

```
1 //clear//
2 clc
3 clear
4 //this code is only for Part C
5 exec("9.2data.sci");
6  t = 55:1:121;
7 function w=f(t,Y)
8
9  w =zeros(2,1);
10
11
12
13 k=.00017*exp(11273/(1.987)*(1/461-1/Y(1)))
14 Qr=UA*(Y(1) -298)
15 Theata=Nbo/Nao
16 ra=-k*(Nao**2)*(1-Y(2))*(Theata-2*Y(2))/(U**2)
17 rate=-ra
18 Qg=ra*U*(dH)
19 w(1)=(Qg-Qr)/NCp
20 w(2)=(-ra)*U/Nao
21 endfunction
22
23 x=ode([467.992;0.0423],t0,t,f);
24
25
26 plot2d(t,x(1,:));
```

```
27
28 xtitle( 'Figure E9-2.2', 't ', 'T (oC)' ) ;
```

Scilab code Exa 9.3 clear

```
1  //clear//
2  clc
3  clear
4  exec("9.3data.sci");
5  t = 0:1:360;
6
7  function w=f(t,Y)
8
9   w =zeros(5,1);
10
11 k=.39175*exp(5472.7*((1/273)-(1/Y(4))));
12 Cd=Y(3);
13
14 Kc=10^(3885.44/Y(4))
15 V=Vi+v0*t;
16 Fb0=Cb0*v0;
17 ra=-k*((Y(1)*Y(2))-((Y(3)*Cd)/Kc));
18 Na=V*Y(1)
19 Nb=V*Y(2)
20 Nc=V*Y(3)
21 rb=ra
22 rc=-ra
23 Nd=V*Cd
24 rate=-ra
25 NCp=cp*(Nb+Nc+Nd+Y(5))+cpa*Na;
26 w(1)=ra-(v0*Y(1))/V;
27 w(2) =rb+(v0*(Cb0-Y(2))/V);
28 w(3) =rc- (Y(3)*v0)/V;
29 w(4)= (UA*(Ta-Y(4))-Fb0*cp*(1+55)*(Y(4)-T0)+ra*V*dh)
     /NCp
```

```
30 w(5) =v0*Cw0
31 endfunction
32
33 x=ode([5;0.0001;00.0001;300;6.14],t0,t,f);
34 scf(1)
35 plot2d(t,x(4,:));
36
37 xtitle( 'Figure E9-3.1', 't', 'T' ) ;
38
39 scf(2)
40 l1=x(1,: )'
41 l2=x(2,: )'
42 l3=x(3,: )'
43 plot2d(t',[l1 l2 l3]);
44
45 xtitle( 'Figure E9-3.2', 't', 'Ca,Cb,Cc' ) ;
46 legend(['Ca';'Cb';'Cc']);
```

Scilab code Exa 9.4 clear

```
1 //clear//
2 clc
3 clear
4 //exec("9.3data.sci");
5 t = 0:.0001:4;
6 t0=0;
7 function w=f(t,Y)
8
9  w =zeros(5,1);
10
11 Fa0=80;
12 T0=75;
13 V=(1/7.484)*500;
14 UA=16000;
15 Ta1=60;
```

```
16 k=16.96e12*exp(-32400/1.987/(Y(5)+460));
17 Fb0=1000;
18 Fm0=100;
19 mc=1000;
20 ra=-k*Y(1);
21 rb=-k*Y(1);
22 rc=k*Y(1) ;
23 Nm=Y(4)*V;
24 Na=Y(1)*V;
25 Nb=Y(2)*V;
26 Nc=Y(3)*V;
27 ThetaCp=35+(Fb0/Fa0)*18+(Fm0/Fa0)*19.5;
28 v0=(Fa0/0.923)+(Fb0/3.45)+(Fm0/1.54);
29 Ta2=Y(5)- (Y(5)-Ta1)*exp (-UA/(18*mc));
30 Ca0=Fa0/v0
31 Cb0=Fb0/v0
32 Cm0=Fm0/v0
33 Q=mc*18*(Ta1-Ta2);
34 tau=V/v0;
35 NCp=Na*35+Nb*18+Nc*46+Nm*13.5;
36 w(1)=(1/tau)*(Ca0-Y(1))+ra;
37 w(2)=(1/tau)*(Cb0-Y(2))+rb;
38 w(3)=(1/tau)*(-Y(3))+rc;
39 w(4) =(1/tau)*(Cm0-Y(4));
40 w(5) = (Q-Fa0*ThetaCp*(Y(5)-T0)+(-36000)*ra*V)/NCp;
41 endfunction
42
43 x=ode([0;3.45;0;0;75],t0,t,f);
44 scf(1)
45 plot2d(t,x(1,:));
46
47 xtitle( 'Figure E9-4.1', 't', 'Ca' ) ;
48
49 scf(2)
50 plot2d(t,x(5,:));
51
52 xtitle( 'Figure E9-4.2', 't', 'T' ) ;
53 scf(3)
```

```
54 plot2d(x(5,:),x(1,:));
55
56 xtitle( 'Figure E9-4.3', 'T', 'Ca' ) ;
```

Scilab code Exa 9.8 clear

```
1  //clear//
2  clc
3  clear
4  exec("9.8data.sci");
5  t = 0:.01:1.5;
6
7  function w=f(t,Y)
8
9   w =zeros(4,1);
10
11 k1a=1.25*exp((9500/1.987)*((1/320)-(1/Y(4))));
12 k2b=0.08*exp((7000/1.987)*((1/290)-(1/Y(4))));
13 ra=-k1a*Y(1);
14 V=100+vo*t;
15 rc=3*k2b*Y(2);
16 rb=k1a*(Y(1)/2)-k2b*Y(2);
17 w(1)=ra+(Cao-Y(1))*vo/V;
18 w(2)=rb-Y(2)*vo/V;
19 w(3)=rc-Y(3)*vo/V; w(4)=(35000*(298-Y(4))-Cao*vo
      *30*(Y(4)-305)+((-6500)*(-k1a*Y(1))+(8000)*(-k2b*
      Y(2)))*V)/((Y(1)*30+Y(2)*60+Y(3)*20)*V+100*35);
20 endfunction
21
22 x=ode([1;0;0;290],t0,t,f);
23
24
25 scf(1)
26 l1=x(1,: )'
27 l2=x(2,: )'
```

```
28 l3=x(3,: )'
29 plot2d(t',[l1 l2 l3]);
30
31 xtitle( 'Figure E9-8.1', 't', 'Ca,Cb,Cc' ) ;
32 legend(['Ca';'Cb';'Cc']);
33
34 scf(2)
35 plot2d(t,x(4,:));
36
37 xtitle( 'Figure E9-8.2', 't', 'T' ) ;
```

Chapter 10

Catalysis and Catalytic Reactors

check Appendix AP 1 for dependency:

10_3.sci

Scilab code Exa 10.3 clear

```
1  //clear//
2  clc
3  clear
4  exec("10.3data.sci");
5  w = 0:10:10000;
6
7  function W=f(w,x)
8
9   W =zeros(1,1);
10
11 pt0=.3*Po;
12 y=(1-alpha*w)^.5;
13 ph=pt0*(1.5-x)*y;
14 pt=pt0*(1-x)*y;
15 pb=2*pt0*x*y;
```

```
rt=-k*kt*ph*pt/(1+kb*pb+kt*pt);
rate=-rt;
W(1)=-rt/ft0;
endfunction
pt0=.3*Po;
X=ode([0],w0,w,f);


for i =1:length(X)
  y(1,i)=(1-alpha*w(1,i))^.5;
ph(1,i)=pt0*(1.5-X(1,i))*y(1,i);
pt(1,i)=pt0*(1-X(1,i))*y(1,i);
pb(1,i)=2*pt0*X(1,i)*y(1,i)
end

m1 = X';
m2=y';
scf(1)
plot2d(w',[m1 m2]);

xtitle( 'Figure E10-3.1', 'w', 'x,y' ) ;
legend(['x';'y']);

scf(2)
l1=ph'
l2=pt'
l3=pb'
plot2d(w',[l1 l2 l3]);

xtitle( 'Figure E10-3.2', 'w', 'ph,pt,pb' ) ;
legend(['ph';'pt';'pb']);
```

Scilab code Exa 10.5 clear

```
//clear//
```

```
clc
clear
exec("10.5data.sci");
t = 0:.01:.5;

function w=f(t,Y)

 w =zeros(2,1);


ya0=Ca0/Ct0;
X=1-(1+ya0)/(1+Y(2)/Ct0)*Y(2)/Ca0;
w(1)=-kd*Y(1)*Y(2);
w(2) = (Ca0/tau)-((1+ya0)/(1+(Y(2)/Ct0))+tau*Y(1)*k)
   *Y(2)/tau;
endfunction

x=ode([1;.8],t0,t,f);
Ca0=.8;
Ct0=1
ya0=Ca0/Ct0;
for i=1:length(t)
  X1(i)=1-(1+ya0)/(1+x(2,i)/Ct0)*x(2,i)/Ca0;
  end


l1=x(1,:)'
l2=x(2,:)'
l3=X1;
plot2d(t',[l1 l2 l3]);

xtitle( 'Figure E10-5.1', 't', 'a,Ca,X' ) ;
legend(['a';'Ca';'X']);
```

Scilab code Exa 1.7 clear

```
1  //clear//
2  clc
3  clear
4  //exec("9.8data.sci");
5  t = 0:.01:.5;
6
7  function w=f(t,Y)
8
9   w =zeros(2,1);
10
11 d(X)/d(z}=-ra/U/Ca0
12 Ka=0.05;
13 Kb=.15;
14 Pao=12;
15 eps=1;
16 A=7.6;
17 R=0.082;
18 T=400+273;
19 Kc=.1;
20 rho=80;
21 kprime=0.0014;
22 D=1.5;
23 Uo=2.5
24 U:Uo*(l+eps*X)
25 Pa=PBo*(l-X)/(ltepstX)
26 Pb=Pao*X/(l+eps*X)
27 vo=Uo*3.1416*D*D/4
28 Ca0=PBo/R/T
29 Kca=Ka*R*T
30 Pc=Pb
31 a=l/(l+At(z/U)**O.S)
32 raprime=at (-kprirne*Pa/(l t Kat Pa+Kb:l:Pb+Kct Pc
33 ra:rhotraprime
34 endfunction
35
36 x=ode([1;.8],t0,t,f);
37 Ca0=.8;
38 Ct0=1
```

```
39 ya0=Ca0/Ct0;
40 for i=1:length(t)
41   X(i)=1-(1+ya0)/(1+x(2,i)/Ct0)*x(2,i)/Ca0;
42   end
43 plot2d(t,x(1,:));
44
45 plot2d(t,x(2,:));
46 plot2d(t,X);
```

Scilab code Exa 10.7 clear

```
1  //clear//
2  clc
3  clear
4  exec("10.7data.sci");
5  z = 0:.1:10;
6  z0=0;
7  function w=f(z,X)
8
9   w =zeros(1,1);
10
11
12 U=Uo*(1+eps*X)
13 Pa=Pao*(1-X)/(1+eps*X)
14 Pb=Pao*X/(1+eps*X)
15 vo=Uo*3.1416*D*D/4
16 Ca0=Pao/R/T
17 Kca=Ka*R*T
18 Pc=Pb
19 a=1/(1+A*(z/U)**0.5)
20 raprime=a*(-kprime*Pa/(1+ Ka*Pa+Kb*Pb+Kc*Pc))
21 ra=rho*raprime;
22 w(1)=-ra/U/Ca0
23 endfunction
24
```

```
25 x=ode([0],z0,z,f);
26 for i=1:length(z)
27 U(1,i)=Uo*(1+eps*x(1,i))
28 a(1,i)=1/(1+A*(z(1,i)/U(1,i))**0.5)
29 end
30
31
32 l1=x(1,:)'
33 l2=a(1,:)'
34
35 plot2d(z',[l1 l2]);
36
37 xtitle( 'Figure E10-7.1', 'z', 'X,a' ) ;
38 legend(['X';'a']);
```

Chapter 11

External Diffusion Effects on Hetrogeneous Reactions

Scilab code Exa 11.1 clear

```
1 //clear//
2 clc
3 clear
4 exec("11.1data.sci");
5 WAZ1=DAB*CT0*(yAb-yAs)/s;
6 WAZ2=c*DAB*CT0*log((1-yAs)/(1-yAb))/s;
7 disp(WAZ1)
8 disp(WAZ2)
```

Scilab code Exa 11.3 clear

```
1 clc
2 clear
3 exec("11.3data.sci");
4 //this is only Part A of the problem.
5 dp=(6*(D^2)*L/4)^(1/3);
```

```
disp("Particle diameter dp =")
disp(dp)
disp("m")
ac=6*(1-phi)*(1/dp);
disp("Surface area pervolume of bed =")
disp(ac)
disp("m^2/m^3")
Re =dp*U/v;
Y=(2*r*Lp+2*r^2)/dp^2;
Reprime=Re/((1-phi)*Y);
DAB=DAB0*(T/T0)^(1.75);
Sc=v/DAB;
Shprime=((Reprime)^.5)*Sc^(1/3);
kc=DAB*(1-phi)*Y*(Shprime)/(dp*phi);
X=1-exp(-kc*ac*z/U);
disp("X =")
disp(X)
```

Scilab code Exa 11.4 clear

```
clc
clear
exec("11.4data.sci")
X2=1-(1/exp((log(1/(1-X1)))*(1/2)*((2)^.5)));
disp("X2 =")
disp(X2)
```

Scilab code Exa 11.5 clear

```
//clear//
clc
clear
exec("11.5data.sci")
```

```
5  X2=1-(1/exp((log(1/(1-X1)))*((T2/T1)^(5/12))));
6  disp("X2 =")
7  disp(X2)
```

Chapter 13

Distributions of Residence Times for Chemical Reactions

Scilab code Exa 13.8 clear

```
1  //clear//
2  clc
3  clear
4  exec("13.8data.sci");
5  z = 0:1:200;
6
7  function w=f(z,x)
8
9   w =zeros(1,1);
10
11 lam=200-z;
12 ca=cao*(1-x)
13 E1=4.44658e-10*(lam^4)-1.1802e-7*(lam^3)+1.35358e
      -5*(lam^2)-.00086
14 5652*lam+.028004;
15 E2=-2.64e-9*(lam^3)+1.3618e-6*(lam^2)-.00024069*lam
      +.015011
16 F1=4.44658e-10/5*(lam^5)-1.1802e-7/4*lam^4+1.35358e
      -5/3*lam^3-.000865652/2*lam^2+.028004*lam;
```

```
17 F2=-(-9.3076e-8*lam^3+5.02846e-5*lam^2-.00941*lam
     +.61823-1)
18 ra=-k*ca^2;
19 if lam< =70
20   E=E1
21 else
22   E=(E2)
23   end
24   if(lam< =70)
25     F=F1
26   else
27     F=F2
28     end
29     EF=E/(1-F)
30     w(1)=-(ra/cao+E/(1-F)*x)
31 endfunction
32
33 X=ode([0],z0,z,f);
34
35 plot2d(z,X);
```

Scilab code Exa 13.9 clear

```
1  clc
2  clear
3  exec("13.9data.sci");
4  t = 0:.1:2.52;
5
6  function w=f(t,Y)
7
8   w =zeros(10,1);
9
10 E1=-2.104*t^4+4.167*t^3-1.596*t^2+0.353*t-.004
11 E2=-2.104*t^4+17.037*t^3-50.247*t^2+62.964*t-27.402
12 rc=k1*Y(1)*Y(2)
```

```
13 re=k3*Y(2)*Y(4)
14 ra=-k1*Y(1)*Y(2)-k2*Y(1)
15 rb=-k1*Y(1)*Y(2)-k3*Y(2)*Y(4)
16 if t< =1.26
17   E=E1
18 else
19   E=E2
20   end
21   rd=k2*Y(1)-k3*Y(2)*Y(4)
22
23   w(1)=ra
24 w(2) =rb
25 w(3) =rc
26 w(6)=Y(1)*E
27 w(7)=Y(2)*E
28 w(8)=Y(3)*E
29 w(4)=rd
30 w(5) =re
31 w(9)=Y(4)*E
32 w(10)=Y(5)*E
33 endfunction
34
35 X=ode([1;1;0;0;0;0;0;0;0;0],t0,t,f);
36
37 plot2d(t,X(1,:));
```

Chapter 14

Models for Nonideal Reactors

Scilab code Exa 14.3 clear

```
1  //clear//
2  clc
3  clear
4
5  t = 0:10:200;
6
7  function w=f(t,Y)
8
9   w =zeros(2,1);
10
11 CTe1=2000-59.6*t+.64*t^2-0.00146*t^3-1.047*10^(-5)*t
       ^4
12 Beta=.1
13 CTe2=921-17.3*t+.129*t^2-0.000438*t^3+5.6*10^(-7)*t
       ^4
14 alpha=.8
15 tau=40
16 if(t<80)
17   CTe=CTe1
18 else
19   CTe=CTe2
```

```
20 end
21
22 w(1)=(Beta*Y(2)-(1+Beta)*Y(1))/alpha/tau
23 w(2)=(Beta*Y(1)-Beta*Y(2))/(1-alpha)/tau
24 endfunction
25
26 X=ode([2000;0],t0,t,f);
27
28 t=t';
29 for i =1:length(t)
30 CTe1(i)=2000-59.6*t(i)+.64*(t(i)^2)-0.00146*(t(i)^3)
      -1.047*(10^(-5))*t(i)^4;
31 CTe2(i)=921-17.3*t(i)+.129*t(i)^2-0.000438*t(i)
      ^3+5.6*10^(-7)*t(i)^4
32 if(t(i)<80)
33   CTe(i)=CTe1(i)
34 else
35   CTe(i)=CTe2(i)
36 end
37 end
38
39
40 l1=X(1,: )';
41 l2=CTe;
42
43 plot2d(t,[l1 l2]);
44
45 xtitle( 'Figure E14-3.1', 't', 'CT1,CTe' ) ;
46 legend(['CT1';'CTe']);
```

Appendix

Scilab code AP 1 data

```
1 ft0=50
2 k=.0000000145*1000*60;
3 kt=1.038;
4 kb=1.39;
5 alpha=0.000098;
6 Po=40;
7 w0=0;
```