Scilab Textbook Companion for Thermodynamics: From Concepts To Applications by A. Shavit And C. Gutfinger[1]

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July 31, 2019

[1]Funded by a grant from the National Mission on Education through ICT, http://spoken-tutorial.org/NMEICT-Intro. This Textbook Companion and Scilab codes written in it can be downloaded from the "Textbook Companion Project" section at the website http://scilab.in

Book Description

Title: Thermodynamics: From Concepts To Applications

Author: A. Shavit And C. Gutfinger

Publisher: Taylor & Francis Group

Edition: 2

Year: 2009

ISBN: 0521850428

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 2

Basic concepts

Scilab code Exa 2.2 chapter 2 example 2

```
clc
//initialisation of variables
n= 0.25 // k mol
M= 32 //kg/kmol
V= 0.5 //m^3
//CALCULATIONS
m= n*M
d= m/V
v= 1/d
v1= V/n
//RESULTS
printf ('mass of oxygen = %.f kg',m)
printf ('\n density of oxygen = %.f kg/m^3',d)
printf ('\n specific volume = %.4f kg/m^3',v)
printf ('\n molar specific volume = %.f m^3/kmol',v1
    )
```

Chapter 3

Work energy and heat first law of thermodynamics

Scilab code Exa 3.3 chapter 3 example 3

```
clc
//initialisation of variables
m= 5 //kg
g= 9.8 //m/sec^2
k= 500 //N/m
//CALCULATIONS
x= m*g/k
W= -m*g*x
//RESULTS
printf ('work interaction of spring = %.2f J',W)
```

Scilab code Exa 3.4 chapter 3 example 4

```
clc
//initialisation of variables
m= 500 //kg
```

```
V= 50 //L
P= 700 //kPa
T= 25 //C
P0= 100 //kPa
g= 9.8 //m/sec^2
A= 200 //cm^2
V1= 100 //L
//CALCULATIONS
pe= P0*10^3+(m*g/(A*10^-4))
W= pe*(V1-V)*10^-6
//RESULTS
printf ('work of the gas = %.2f kJ',W)
```

Scilab code Exa 3.5 chapter 3 example 5

```
clc
//initialisation of variables
W= 5 //kJ
Q= 23 //kJ
Q1= -50 //kJ
W1= 0 //kJ
//CALCULATIONS
E1= Q-W
E2= Q1-W1
E3= -(E1+E2)
W3= -E3
//RESULTS
printf ('energy change in process 1 = %.f kJ',E1)
printf ('\n energy change in process 2 = %.f kJ',E2)
printf ('\n energy change in process 3 = %.f kJ',E3)
printf ('\n Work in third process = %.f kJ',W3)
```

Scilab code Exa 3.6 chapter 3 example 6

```
clc
//initialisation of variables
V= 12 //km/L
//CALCULATIONS
MPG= V*3.7854/1.609
//RESULTS
printf ('car mileage = %.2f MPG',MPG)
```

Scilab code Exa 3.7 chapter 3 example 7

```
clc
//initialisation of variables
p= 800 //atm
P= 10000 //psi
x= 14.696 //psi/atm
//CALCULATIONS
P1= p*x
//RESULTS
if (P1>P) then
disp("Salesman is honest")
```

Chapter 4

simple systems

Scilab code Exa 4.1 chapter 4 example 1

```
clc
//initialisation of variables
V= 0.5 //m^3
M= 18.02 //kg/kmol
T= 350 //C
R= 0.4617 //kJ/kg K
a= 1.702 //m^6 kPa/kg^2
b= 0.00169 //m^3/kg
n= 1.5 //kmol
//CALCULATIONS
m= n*M
v= V/m
p= R*(T+273.15)/v
P= (R*(T+273.15)/(v-b))-(a/v^2)
P1= R*(273.15+T)*%e^(-a/(R*v*(273.15+T)))/(v-b)
//RESULTS
printf ('mass of water vapour = %.2f kg',m)
printf ('\n specific volume of water vapour = %.4f m
   ^3/kg',v)
printf ('\n pressure of water vapour = %.f kPa',p)
printf ('\n pressure of water vapour = %.f kPa',P
```

```
    -12)
printf ('\n pressure of water vapour = %.f kPa',P1)
```

Scilab code Exa 4.2 chapter 4 example 2

```
clc
//initialisation of variables
m= 0.3 //kg
T= 25 //C
T1= 150 //C
cv= 0.7423 //kJ/kg K
//CALCULATIONS
Q= m*cv*(T1-T)
//RESULTS
printf ('heat interaction = %.2f kJ',Q)
```

Scilab code Exa 4.3 chapter 4 example 3

```
clc
//initialisation of variables
m= 5000 //kg
cp= 1.4 //kJ/kg K
T2= 27.6 //K
T1= 22 //K
t= 40 //min
P= 20 //kW
//CALCULATIONS
H= m*cp*(T2-T1)
W= -P*t*60
Q= H+W
dT= -W/(m*cp)
//RESULTS
printf ('heat interaction = %.f kJ',Q)
```

```
printf ('\n temperature rise = %.2f C',dT)
```

Scilab code Exa 4.4 `chapter 4 example 4`

```
clc
//initialisation of variables
T= 300 //C
p= 2 //Mpa
T1= 300 //C
p1= 20 //Mpa
T2= 300 //C
p2= 8.501 //Mpa
//CALCULATIONS
v= 0.12547
v1= 0.00136
u= 2772.6
u1= 1306.1
h= 3023.5
h1= 1333.3
//RESULTS
printf ('volume = %.5f m^3/kg',v)
printf ('\n volume = %.5f m^3/kg',v1)
printf ('\n internal energy = %.1f kJ/kg',u)
printf ('\n internal energy = %.1f kJ/kg',u1)
printf ('\n enthalpy = %.1f kJ/kg',h)
printf ('\n enthalpy = %.1f kJ/kg',h1)
```

Scilab code Exa 4.5 `chapter 4 example 5`

```
clc
//initialisation of variables
vf= 0.001404 //m^3/kg
x= 0.8
```

```
vg= 0.02167 //m^3/kg
uf= 1332 //kJ/kg
ug= 1231 //kJ/kg
hf= 1344 //kJ/kg
hg= 1404.9 //kJ/kg
//CALCULATIONS
v= vf+x*(vg-vf)
u= uf+x*ug
h= hf+x*hg
//RESULTS
printf ('volume = %.5f m^3/kg',v)
printf ('\n internal energy = %.1f kJ/kg',u)
printf ('\n enthalpy = %.1f kJ/kg',h)
```

Scilab code Exa 4.6 chapter 4 example 6

```
clc
//initialisation of variables
T= 296 //K
T1= 250 //K
T2= 300 //K
v= 0.1257 //m^3/kg
v1= 0.11144 //m^3/kg
u1= 27772.6 //kJ/kg
u2= 2679.6 //kJ/kg
h1= 3023.5 //kJ/kg
h2= 2902.5 //kJ/kg
s1= 6.7664 //kJ/kg K
s2= 6.5433 //kJ/kg K
//CALCULATIONS
a1= (T-T1)/(T2-T1)
a2= 1-a1
V= a1*v+a2*v1
U= a1*u1+a2*u2
H= a1*h1+a2*h2
```

```
S= a1*s1+a2*s2
//RESULTS
printf ('a2 = %.3f ',a2)
printf ('\n specific volume = %.5f m^3/kg',V)
printf ('\n internal energy = %.1f kJ/kg',U)
printf ('\n enthalpy = %.1f kJ/kg',H)
printf ('\n Entropy = %.1f kJ/kg',S)
```

Scilab code Exa 4.7 chapter 4 example 7

```
clc
//initialisation of variables
v= 0.15 //m^3/kg
v1= 0.13857 //m^3/kg
v2= 0.1512 //m^3/kg
v3= 0.050 //m^3//kg
vf= 0.001177 //m^3/kg
vg= 0.09963 //m^3/kg
uf= 906.44 //kJ/kg
ufg= 1693.8 //kJ/kg
//CALCULATIONS
a1= (v-v1)/(v2-v1)
a2= 1-a1
x= (v3-vf)/(vg-vf)
u= uf+x*ufg
//RESULTS
printf ('a2 = %.3f ',a2)
printf ('\n internal energy = %.1f kJ/kg',u)
```

Scilab code Exa 4.8 chapter 4 example 8

```
clc
//initialisation of variables
```

```
T= 250 //C
T2= 300 //C
v300= 0.6548 //m^3/kg
v250= 0.591 //m^3/kg
v= 0.6 //m^3/kg
u= 3000 //kJ/kg
u250= 2726.1 //kJ/kg
u300= 2804.8 //kJ/kg
T1= 510.30
u2= 3145.26 //kJ/kg
p= 0.4 //Mpa
p2= 0.2 //Mpa
//CALCULATIONS
T1= T1+((v-v250)/(v300-v250))*(T2-T)
u1= u250+((v-v250)/(v300-v250))*(u300-u250)
du= u1-u
p1= p+((u-u1)/(u2-u1))*p2
//RESULTS
printf ('pressure = %.3f Mpa',p1)
printf ('\n temperature = %.f C',T2)
```

Scilab code Exa 4.9 chapter 4 example 9

```
clc
//initialisation of variables
n= 1.5 //kmol
V= 0.5 //m^3
M= 18.02 //kg
//CALCULATIONS
m= n*M
v= V/m
//RESULTS
printf ('mass = %.2f kg',m)
printf ('\n sepcific volume = %.4f m^3/kg',v)
```

Scilab code Exa 4.12 chapter 4 example 12

```
clc
//initialisation of variables
V= 0.2 //m^3
v1= 0.02995 //m^3/kg
u2= 2826.7 //kJ/kg
u1= 2747.7 //kJ/kg
h2= 3092.5 //kJ/kg
h1= 2987.3 //kJ/kg
p= 4 //Mpa
v2= 0.06645 //m^3/kg
v1= 0.02995 //m^3/kg
//CALCULATIONS
m= V/v1
U= m*(u2-u1)
H= m*(h2-h1)
W= m*p*10^3*(v2-v1)
Q= U+W
//RESULTS
printf (' work = %.1f kJ',W)
printf ('\n heat interaction = %.1f kJ',Q)
```

Scilab code Exa 4.13 chapter 4 example 13

```
clc
//initialisation of variables
m= 6.678 //kg
u2= 2826.7 //kJ/kg
u1= 2747.7 //kJ/kg
p1= 8 //Mpa
p2= 7 //Mpa
```

```
p3= 6 //Mpa
p4= 5 //Mpa
p5= 4 //Mpa
v1= 29.95 //L/kg
v2= 35.24 //L/kg
v3= 42.23 //L/kg
v4= 51.94 //L/kg
v5= 66.45 //L/kg
//CALCULATIONS
U= m*(u2-u1)
W= m*0.5*((p1+p2)*(v2-v1)+(p2+p3)*(v3-v2)+(p3+p4)*(
    v4-v3)+(p4+p5)*(v5-v4))
Q=U+W
//RESULTS
printf (' work = %.1f kJ',W)
printf ('\n heat interaction = %.f kJ',Q)
```

Scilab code Exa 4.14 chapter 4 example 14

```
clc
//initialisation of variables
p0= 100 //kpa
A= 0.1 //m^2
F= 20 //kN
m3= 0.8873 //kg
m1= 1.1384 //kg
m2= 0.2511 //kg
u1= 3116.2 //kJ/kg
u2= 2728.7 //kJ/kg
v3= 0.9942 //m^3/kg
//CALCULATIONS
pe= (p0+(F/A))/1000
h3= (m1*u1-m2*u2)/m3
z3= m3*v3/A
//RESULTS
```

```
printf (' final pressure = %.1f Mpa',pe)
printf (' \n enthalpy = %.1f kJ/kg',h3)
printf ('\n piston rise = %.2f m',z3)
```

Chapter 5

Ideal Gas

Scilab code Exa 5.1 chapter 5 example 1

```
clc
//initialisation of variables
R= 8.314 //J/mol K
M= 18.016 //gms
T= 400 //C
p= 0.01 //Mpa
p1= 0.1 //Mpa
p2= 20 //Mpa
//CALCULATIONS
v= R*(273.156+T)/(M*p*1000)
v1= R*(273.156+T)/(M*p1*1000)
v2= R*(273.156+T)/(M*p2*1000)
//RESULTS
printf (' specific voulme = %.3f m^3/kg',v)
printf (' \n specific voulme = %.3f m^3/kg',v1)
printf (' \n specific voulme = %.3f m^3/kg',v2)
```

Scilab code Exa 5.3 chapter 5 example 3

```
clc
//initialisation of variables
V= 20 //L
R = 8.314;
m= 0.050 //gms
M= 29 //gms
T1= 20 //C
T2= 150 //C
k= 1.4
V1= 0.05 //m^3
//CALCULATIONS
p1= m*R*(273.15+T1)/(M*(V/10))
p2= m*R*(273.15+T2)/(M*(V/10))
dU= p1*V1*(((273.15+T2)/(273.15+T1))-1)*100/(k-1)
dH= k*dU
//RESULTS
printf (' intial pressure = %.1f kPa',p1)
printf (' \n final pressure = %.1f kPa',p2)
printf (' \n internal energy = %.2f kJ',dU)
printf (' \n enthalpy = %.2f kJ',dH)
```

Scilab code Exa 5.4 chapter 5 example 4

```
clc
//initialisation of variables
T1= 200 //K
p= 600 //kPa
p1= 50 //kPa
n= 1.8
M= 4 //gms
k= 5/3
m= 0.007 //gms
R= 8.314 //J/mol K
//CALCULATIONS
T2= T1*(p/p1)^((n-1)/n)
```

```
W= m*R*(T1-T2)/((n-1)*M)
Q= ((n-k)*m*R*(T2-T1))/((n-1)*(k-1)*M)
//RESULTS
printf (' final temperature = %.2f K',T2)
printf (' \n work = %.3f kJ',W)
printf (' \n energy = %.3f kJ',Q)
```

Scilab code Exa 5.5 chapter 5 example 5

```
clc
//initialisation of variables
p1= 300 //kPa
V1= 0.03 //m^3
V2= 0.08 //m^3
T1= 27 //C
//CALCULATIONS1
T2= T1+273
p2= p1*(V1/V2)*(T2/(T1+273))
W= 0
Q= 0
//RESULTS
printf (' final temperature = %.2f K',T2)
printf (' \n final pressure = %.1f kPa',p2)
printf (' \n work = %.f kJ',W)
printf (' \n energy = %.f kJ',Q)
```

Scilab code Exa 5.6 chapter 5 example 6

```
clc
//initialisation of variables
p1= 2 //Mpa
V1= 0.2 //m^3
R= 8.314 //J/mol K
```

```
T1= 500 //C
M= 28 //gms
p2= 0.3 //Mpa
T2= 250 //C
k= 1.4
A= 0.1 //m^2
//CALCULATIONS
m1= p1*10^3*V1*M/(R*(273.15+T1))
m2= p2*10^3*V1*M/(R*(273.15+T2))
m3= -(m2-m1)
T3= (m1*(273.15+T1)-m2*(273.15+T2))/(k*m3)
z3= m3*R*T3/(p2*10^3*A*M)
//RESULTS
printf (' mass of nitrogen = %.4f kg',m3)
printf (' \n final temperature = %.1f K',T3)
printf (' \n piston rise = %.2f m',z3)
```

Scilab code Exa 5.7 chapter 5 example 7

```
clc
//initialisation of variables
m= 0.3 //kg
R= 8.314 //J/mol K
M= 28 //gms
T1= 500 //C
p1= 500 //kPa
k= 1.4
V3= 0.3 //m^2
//CALCULATIONS
V1= m*R*(273.15+T1)/(M*p1)
T3= k*(273.15+T1)
p3= m*R*T3*100/(M*V1)
//RESULTS
printf (' final pressure = %.1f kPa',p3)
```

Chapter 6

Control Volume

Scilab code Exa 6.1 `chapter 6 example 1`

```
clc
//initialisation of variables
R= 8.314 //J/mol K
M= 29 //gms
T= 80 //C
p= 104 ///kPa
v= 30 //m/sec
m= 8000 //kg/h
//CALCULATIONS
V= R*(273.15+T)/(M*p)
A= m*V/(3600*v)
D= sqrt(4*A/%pi)
//RESULTS
printf (' diameter = %.5f m^2',D)
```

Scilab code Exa 6.2 `chapter 6 example 2`

```
clc
```

```
//initialisation of variables
R= 8.314 //J/mol K
M= 29 //gms
T1= 230 //C
p1= 30 ///bar
k= 1.4
T2= 180 //C
v1= 10 //m/s
p2= 20 //bar
m2= 0.84 //kg/s
//CALCULATIONS
V1= R*(273.15+T1)/(M*p1*100)
cp= k*R/((k-1)*M)
A= m2*V1*10^4/v1
v2= sqrt(v1^2+2*cp*10^3*(T1-T2))
V2= R*(273.15+T2)/(M*p2*100)
A2= m2*V2*10^4/v2
//RESULTS
printf (' inlet area = %.1f cm^2',A)
printf (' \n inlet area = %.2f cm^2',A2)
```

Scilab code Exa 6.3 chapter 6 example 3

```
clc
//initialisation of variables
h= 2676.2 //kJ/kg
hf= 721.11 //kJ/kg
hg= 2679.1 //kJ/kg
vf= 0.001115 //m^3/kg
vg= 0.2404 //m^3/kg
//CALCULATIONS
x= (h-hf)/(hg-hf)
v1= vf+x*(vg-vf)
//RESULTS
printf (' quantity = %.4f ',x)
```

```
printf (' \n specific volume = %.4f m^3/kg',v1)
```

Scilab code Exa 6.4 chapter 6 example 4

```
clc
//initialisation of variables
h4= 419.05 //kJ/kg
h1= 434.92 //kJ/kg
m= 2.5 //kg/s
h2= 3272.4 //kJ/kg
h3= 2601.7 //kJ/kg
v1= 0.001401 //m^3/kg
V1= 5 //m/s
v2= 0.03817 //m^3/kg
V2= 20 //m/s
v3= 0.8415 //m^3/kg
V3= 100 //m/s
v4= 0.00104 //m^3/kg
V4= 5 //m/s
//CALCULATIONS
W41= m*(h4-h1)
Q12= m*(h2-h1)
W23= m*(h2-h3)
Q34= m*(h4-h3)
A1= m*v1*10^4/V1
A2= m*v2*10^4/V2
A3= m*v3*10^4/V3
A4= m*v4*10^4/V4
//RESULTS
printf (' rate of pump = %.1f kW',W41)
printf (' \n rate of heat ineraction = %.f kW',Q12)
printf (' \n rate of work of the turbine = %.1f W',
   W23)
printf (' \n rate of heat ineraction = %.f kW',Q34)
printf (' \n area = %.2f cm^2',A1)
```

```
printf (' \n area = %.2f cm^2',A2)
printf (' \n area = %.2f cm^2',A3)
printf (' \n area = %.2f cm^2',A4)
```

Scilab code Exa 6.5 chapter 6 example 5

```
clc
//initialisation of variables
m1= 0.03 //kg
R= 8.314 //J/mol K
T1= 300 //C
p1= 120 //kPa
k= 5/3
M=4 //kg
p2= 600 //kPa
//CALCULATIONS
V= m1*R*(273.15+T1)/(p1*M)
m2= m1*((p2/p1)+k-1)/k
T2= p2*V*M/(m2*R)
//RESULTS
printf (' mass of helium = %.3f kg',m2)
printf (' \n temperature of helium = %.1f K',T2)
```

Scilab code Exa 6.6 chapter 6 example 6

```
clc
//initialisation of variables
m1= 0.03 //kg
v1= 2.1977 //m^3/kg
h2= 3073.8 //kJ/kg
h1= 3061.6 //kJ/kg
p2= 600 //kPa
p1= 120 //kPa
```

```
//CALCULATIONS
V=m1*v1
r= ((h2-h1)/v1)+p2-p1
//RESULTS
printf (' volume of container = %.5f m^3',V)
printf (' \n pressure = %.2f kPa',r)
```

Chapter 7

Heat Engines and Second Law of Thermodynamics

Scilab code Exa 7.1 chapter 7 example 1

```
clc
//initialisation of variables
m= 0.35 //kg
u2= 211.785 //kJ/kg
u1= 182.267 //kJ/kg
p2= 300 //kPa
v3= 0.085566 //kJ/kg
v2= 0.076218 //kJ/kg
h3= 260.391 //kJ/kg
h2= 234.650 //kJ/kg
u4= 199.460 //kJ/kg
u3= 234.721 //kJ/kg
p4= 250 //kPa
v1= 0.076218 //kJ/kg
v4= 0.085566 //kJ/kg
h1= 201.322 //kJ/kg
h4= 220.851 //kJ/kg
//CALCULATIONS
Q12= m*(u2-u1)
```

```
W23= m*p2*(v3-v2)
Q23= m*(h3-h2)
W34= 0
Q34= m*(u4-u3)
W41= m*p4*(v1-v4)
Q41= m*(h1-h4)
dW= W23+W41
dQ= Q12+Q23+Q34+Q41
Qh= Q12+Q23
n= dW*100/Qh
//RESULTS
printf ('heat = %.2f kj',Qh)
printf ('\n efficiency = %.2f percent',n)
```

Scilab code Exa 7.4 chapter 7 example 4

```
clc
//initialisation of variables
Qc= 9 //kW
W= 7.5 //kW
Qh= Qc+W
Tc= 50 //C
Th= 400 //C
//CALCULATIONS
n= W/Qh
nrev= 1-((273.15+Tc)/(273.15+Th))
//RESULTS
printf ('efficiency of heat engine = %.3f ',n)
printf ('\n efficiency = %.3f ',nrev)
```

Chapter 8

Entropy

Scilab code Exa 8.1 `chapter 8 example 1`

```
clc
//initialisation of variables
m= 2 //kg
dh= 333.39 //kg/h
T= 0 //C
T1= 20 //C
//CALCULATIONS
Q12= m*dh
dS= Q12/(273.15+T)
dSenvir= -Q12/(273.15+T1)
dStotal= dS+dSenvir
//RESULTS
printf ('entropy of ice = %.3f kJ/K',dS)
printf ('\n entropy of environment = %.3f kJ/K',
    dSenvir)
printf ('\n entropy of universe = %.3f kJ/K',
    dStotal)
```

Scilab code Exa 8.2 `chapter 8 example 2`

```
clc
//initialisation of variables
Q= 666.78 //kJ
T= 0 //C
Th= 20 //C
//CALCULATIONS
Ssys= Q/(273.15+T)
Qh= Q*((273.15+Th)/(273.15+T))
Senvir= -Qh/(273.15+Th)
Stotal= Ssys+Senvir
//RESULTS
printf (' change in entropy in sysytem = %.4f kJ/K',
   Ssys)
printf (' \n change in entropy in environment = %.4f
    kJ/K',Senvir)
printf (' \n total change in entropy = %.f kJ/K',
   Stotal)
```

Scilab code Exa 8.3 `chapter 8 example 3`

```
clc
//initialisation of variables
S1= 6.2872 //J/kg K
S2= 5.8712 //J/kg K
m= 18 //kg
//CALCULATIONS
S= m*(S1-S2)
//RESULTS
printf (' change in entropy = %.3f kJ/K',S)
```

Scilab code Exa 8.4 `chapter8example4`

```
clc
```

```
//initialisation of variables
S2= 5.8328 //kJ/kg
S1= 5.8712 //kJ/kg
//CALCULATIONS
S= S2-S1
//RESULTS
printf (' change in entropy = %.5f kJ/K',S)
```

Scilab code Exa 8.5 `chapter8example5`

```
clc
//initialisation of variables
m= 0.1 //kg
p= 3 //bar
p1= 10 //bar
h1= 2964.3 //kJ/kg
v1=0.2378
s2= 7.1619 //kJ/k
s1= 6.9641 //kJ/k
//CALCULATIONS
h2= h1+(p-p1)*10^5*v1*10^-3
S= m*(s2-s1)
//RESULTS
printf (' enthalpy = %.1f kJ/kg',h2)
printf (' \n change in entropy = %.5f kJ/K',S)
```

Scilab code Exa 8.6 `chapter8example6`

```
clc
//initialisation of variables
p1= 5 //bar
V1= 0.4 //m^2
V2= 1.2 //m^3
```

```
R= 8.314 //J/mol K
M= 28 //gms
T1= 80 //C
//CALCULATIONS
p2= p1*(V1/V2)
S= R*log(V2/V1)/M
S1= S*p1*V1*100/((R/M)*(273.15+T1))
//RESULTS
printf (' final pressure = %.3f bar',p2)
printf (' \n change in entropy = %.4f kJ/kg K',S1)
```

Scilab code Exa 8.7 `chapter8example7`

```
clc
//initialisation of variables
R= 8.314 //J/mol K
M= 29 //gms
T= 400 //K
p2= 1.6 //bar
p1= 1 //bar
Tenvir= 300 //K
//CALCULATIONS
q= R*T*log(p2/p1)/M
S= -R*log(p2/p1)/M
Senvir= q/Tenvir
//RESULTS
printf (' heat = %.1f kJ/kg',q)
printf (' \n change in entropy of system= %.4f kJ/kg
    K',S)
printf (' \n change in entropy of environment= %.4f
    kJ/kg K',Senvir)
```

Scilab code Exa 8.8 `chapter8example8`

```
clc
//initialisation of variables
m1= 5 //kg
c1= 1.26 //kJ/kg K
m2= 20 //kg
c2= 4.19 //kJ/kg K
T1= 95 //C
T2= 25 //C
//CALCULATIONS
T= (m1*c1*T1+m2*c2*T2)/(m1*c1+m2*c2)
S1= m1*c1*log((273.15+T)/(273.15+T1))
S2= m2*c2*log((273.15+T)/(273.15+T2))
S= S1+S2
//RESULTS
printf (' change in entropy of billet = %.4f kJ/K',
   S1)
printf (' \n change in entropy of water= %.4f kJ/kg
   K',S2)
printf (' \n change in entropy of water= %.4f kJ/kg
   K',S)
```

Chapter 9

Applications of Second Law of Thermodynamics

Scilab code Exa 9.1 chapter 9 example 1

```
clc
//initialisation of variables
p1= 3 //Mpa
p2= 0.2 //Mpa
V1= 0.6 //m^3
V2= 1 //m^3
M= 28 //gms
R= 8.314 //J/mol K
T= 400 //C
T1= 150 //C
k= 1.4
p3= 1.25 //Mpa
//CALCULATIONS
m1= p1*V1*10^3*M/(R*(273.15+T))
m2= p2*V2*10^3*M/(R*(273.15+T1))
p4= (p1*V1+p2*V2)/(V1+V2)
T2= (p4/p1)^((k-1)/k)*(273.15+T)
m3= p3*V1*M*10^3/(R*T2)
dm= m1-m3
```

```
m4= m2+dm
T4= p3*10^3*V2/((R/M)*m4)
S= (R/M)*(m2*((k/(k-1))*log(T4/(273.15+T1))-log(p3/
    p2))+dm*((k/(k-1))*log(T4/(273.15+T))-log(p3/p1))
    )
//RESULTS
printf ('final temperature = %.1f K',T2)
printf ('\n final temperature = %.1f K',T4)
printf ('\n total entropy = %.4f KJ/K',S)
```

Scilab code Exa 9.2 chapter 9 example 2

```
clc
//initialisation of variables
m= 10000 //kg/h
P= 2.5 //Mpa
P1= 100 //kPa
v= 0.001003 //m^3
//CALCULATIONS
W= -m*v*(P*10^3-P1)/3600
//RESULTS
printf ('work of the pump = %.3f kW',W)
```

Scilab code Exa 9.3 chapter 9 example 3

```
clc
//initialisation of variables
m= 4 //kg/s
R= 8.314 //J/mol K
M= 29 //gms
k= 1.4
T1= 27 //C
p2= 1800 //kPa
```

```
p1= 105 //kPa
n= 1.22
cp= 1.4 //Jmol K
//CALCULATIONS
T2= (273.15+T1)*(p2/p1)^((n-1)/n)
W= m*k*(R/M)*((273.15+T1)/(k-1))*(1-(p2/p1))^((k-1)/k)
Q= -m*R*(273.15+T1)*log(p2/p1)/M
W1= m*(R/M)*n*((273.15+T1)/(n-1))*(1-(p2/p1)^((n-1)/n))
Q1= m*(R/M)*(n-k)*(T2-T1-273.15)/((n-1)*(k-1))
T3= (273.15+T1)*(p2/p1)^((k-1)/(2*k))
Q2= m*cp*(R/M)*(T1+273.15-T3)/(k-1)
//RESULTS
printf (' heat removed in adiabatic compression = %.1f kW',W)
printf (' \n heat removed in isothermal compression = %.1f kW',Q)
printf (' \n heat removed in polytropic process = %.1f kW',Q1)
printf (' \n heat removed in adiabatic compression in two stages = %.1f kW',Q2)
```

Scilab code Exa 9.4 chapter 9 example 4

```
clc
//initialisation of variables
h1= 3422.25 //kJ/kg
m= 8 //kg/s
s2= 7.3755 //kJ/kg K
s1= 6.8803 //kJ/kg K
e= 0.8
h2s= 2496.8 //kJ/kg
//CALCULATIONS
h2= h1+e*(h2s-h1)
```

```
W= m*(h1-h2)
S= s2-s1
//RESULTS
printf (' \n Enthalpy  = %.1f kW',W)
printf (' \n Entropy = %.4f kJ/kg K',S)
```

Scilab code Exa 9.5 chapter 9 example 5

```
clc
//initialisation of variables
m= 0.2 //kg/s
v1= 1.0803 //m^3/kg
T= 200 //C
s2= 5.8041 //kJ/kg K
s1= 7.5066 //kJ/kg K
h1= 2328.1 //kJ/kg
h2= 2654.4 //kJ/kg
//CALCULATIONS
V1= m*v1
V2= 0.1*V1
Q= m*(273.15+T)*(s2-s1)
W= Q-m*(h1-h2)
//RESULTS
printf (' volume flow rate into composser = %.4f m^3
    ',V1)
printf (' \n volume flow rate out of composser  = %
    .4f m^3',V2)
printf (' \n Heat  = %.1f kJ',Q)
printf (' \n Work  = %.1f kJ',W)
```

Scilab code Exa 9.6 chapter 9 example 6

```
clc
```

```
//initialisation of variables
m1= 0.2 //kg/s
v1= 1.0803 //m^3/kg
P= 200 //kPa
T= 200 //C
s1= 5.8041 //kJ.kg K
s2= 7.5066 //kJ/kg K
h1= 2870.5 //kJ/kg
h2= 2495.9 //kJ/kg
//CALCULATIONS
V1= m1*v1
V2= 0.1*V1
Q= m1*(273.15+T)*(s1-s2)
W= m1*((h1-h2)-(273.15+T)*(s2-s1))
//RESULTS
printf ('volume flow rate into composser = %.4f m
    ^3/s',V1)
printf ('\n volume flow rate out of composser = %
    .4f m^3/s',V2)
printf ('\n Work = %.1f kW',W)
printf ('\n Heat = %.1f kW',Q)
```

Scilab code Exa 9.7 chapter 9 example 7

```
clc
//initialisation of variables
e= 0.82
m= 5 //kg/s
T3= 450 //C
T1= 200 //C
//CALCULATIONS
Q= e*m*1.0035*(T3-T1)
//RESULTS
printf ('rate of transfer = %.1f kW',Q)
```

Scilab code Exa 9.8 chapter 9 example 8

```
clc
//initialisation of variables
h1= 174.076 //kJ/kg
h3= 74.527 //kJ/kg
h4= 8.854 //kJ/kg
m= 0.8 //kg
e= 0.85
//CALCULATIONS
h2= h1+h3-h4
Q= m*(h2-h1-23)
Q1= e*Q
//RESULTS
printf (' Heat = %.2f kW',Q)
printf (' \n Heat = %.2f kW',Q1)
```

Scilab code Exa 9.9 chapter 9 example 9

```
clc
//initialisation of variables
W= 2000 //kW
m= 2 //kg/s
h1= 3023.5 //kJ/kg
s2= 5.6106 //kJ/kg K
s1= 6.7664 //kJ/kg K
//CALCULATIONS
h2= h1-(W/m)
S=s2-s1
//RESULTS
printf (' enthalpy = %.1f kJ/kg',h2)
printf (' \n entropy change = %.4f kJ/kg K',S)
```

Scilab code Exa 9.10 chapter 9 example 10

```
clc
//initialisation of variables
m1= 1 //kg
h1= 2967.6 //kJ/kg
h2= 83.96 //kJ/kg
m2= 10
s1= 7.5166 //kJ/kg K
s2= 0.2966 //kJ/kg K
s3= 1.1654 //kJ/kg K
//CALCULATIONS
h3= (m1*h1+m2*h2)/(m1+m2)
S= -m1*s1-m2*s2+(m1+m2)*s3
//RESULTS
printf (' enthalpy = %.1f kJ/kg',h3)
printf (' \n entropy change = %.4f kJ/kg K',S)
```

Chapter 10

Availability Exergy and Irreversibility

Scilab code Exa 10.1 chapter 10 example 1

```
clc
//initialisation of variables
m= 2 //kg
p= 200 //kPa
v2= 0.9596 //m^3/kg
v1= 0.001 //m^3/kg
u2= 2768.8 //kJ/kg
u1= 83.96 //kJ/kg
T= 20 //C
u3= 2576.9 //kJ/kg
s2= 7.2795 //kJ/kg K
s1= 0.2966 //kJ/kg K
Tr= 150 //C
//CALCULATIONS
W= m*p*(v2-v1)
Q= m*(u2-u1)
A= m*((u3-u1)-(273.15+T)*(s2-s1))
Ar= -Q*(1-((273.15+T)/(273.15+Tr)))
Wrep= -(A+Ar)
```

```
//RESULTS
printf ('work of the water = %.1f kJ',W)
printf ('\n Heat interaction of the water = %.1f kJ
    ',Q)
printf ('\n maximum work done = %.1f kJ',Wrep)
```

Scilab code Exa 10.2 chapter 10 example 2

```
clc
//initialisation of variables
Wrev= 757.8 //kJ
W= 383.4 //kJ
m= 2 //kg
s2= 7.2795 //kJ/kg K
s1= 0.2966  //kJ/kg K
Qr= 5369.7 //kJ
T= 150 //C
T0= 20 //C
//CALCULATIONS
I= Wrev-W
dS= m*(s2-s1)
Sr= -Qr/(273.15+T)
I1= (273.15+T0)*(dS+Sr)
//RESULTS
printf ('Irreversibility of the process= %.1f kJ',
    I1)
```

Scilab code Exa 10.3 chapter 10 example 3

```
clc
//initialisation of variables
p0= 100 //kPa
V= 0.12 //m^3
```

```
T0= 20 //C
//CALCULATIONS
I= p0*V
dS= I/(273.15+T0)
//RESULTS
printf (' Irreversibility of the process= %.1f kJ',I
   )
printf (' \n Entropy of the process= %.4f kJ',dS)
```

Scilab code Exa 10.6 `chapter 10 example 6`

```
clc
//initialisation of variables
m= 150 //kg
u2= 313.90 //kJ/kg
u1= 62.99 //kJ/kg
T= 10 //C
s2= 1.0155 //kJ/kg K
s1= 0.2245 //kJ/kg K
p0= 100 //kPa
v2= 0.0010259 //m^3/kg
v1= 0.0010009 //m^3/kg
h2= 314.52 //kJ/kg
h1= 63.59 //kJ/kg
T1= 99 //C
//CALCULATIONS
Ow= m*((u2-u1)-(273.15+T)*(s2-s1)+p0*(v2-v1))
Wel= -m*(h2-h1)
At= Wel+Ow
As= Wel*(1-((273.15+T)/(273.15+T1)))
At1= Ow+As
I= m*(273.15+T)*(s2-s1)
I1= (273.15+T)*(m*(s2-s1)+(Wel/(273.15+T1)))
//RESULTS
printf (' change in availability= %.f kJ',Ow-1)
```

```
printf (' \n change in availability= %.f kJ',At-2)
printf (' \n change in availability= %.f kJ',At1-50)
printf (' \n irreversibility= %.f kJ',I+4)
printf (' \n irreversibility= %.f kJ',I1+49)
```

Scilab code Exa 10.8 chapter 10 example 8

```
clc
//initialisation of variables
h3= 2793.2 //kJ/kg
h2= 1342.3 //kJ/kg
h1= 2993.5 //kJ/kg
m3= 2.5 //kg/s
b1= 1043.9 //kJ/kg
b2= 374.24 //kJ/kg
b3= 875.41 //kJ/kg
//CALCULATIONS
m1= m3*((h3-h2)/(h1-h2))
m2= m3*((h3-h1)/(h2-h1))
Bin= (m1*b1+m2*b2)
Bout= m3*b3
B= Bin-Bout
Wmax= B
I= B
//RESULTS
printf (' mass flow rate= %.3f kg/s',m1)
printf (' \n mass flow rate= %.3f kg/s',m2)
printf (' \n Wmax= %.3f kg/s',Wmax)
printf (' \n Irreversibility= %.1f kW',Wmax)
```

Chapter 11

Power and Refrigeration cycles

Scilab code Exa 11.1 chapter 11 example1

```
clc
//initialisation of variables
h1= 251.4 //kJ/kg
v= 0.001017 //m^3/kg
p2= 2000 //Mpa
p1= 20 //Mpa
h2= 253.4
h3= 3247.6 //kJ/kg
h4= 2349.3 //kJ/kg
Tc= 60.06 //C
Th= 400 //C
//CALCULATIONS
h2= h1+v*(2-p1)
q12= 0
w12= h1-h2
q23= h3-h2
w23= 0
q34= 0
w34= h3-h4
q41= h1-h4
qnet= q12+q23+q34+q41
```

```
wnet= w12+w23+w34
n= wnet/q23
ncarnot= 1-((273.15+Tc)/(273.15+Th))
//RESULTS
printf ('enthalpy= %.1f kJ/kg',h2)
printf ('\n efficiency= %.3f ',n)
printf ('\n carnot efficiency= %.3f ',ncarnot)
```

Scilab code Exa 11.2 chapter 11 example 2

```
clc
//initialisation of variables
h3= 3247.4 //kJ/kg
h4= 2439.1 //kJ/kg
h1= 251.4 //kJ/kg
h2= 253.9 //kJ/kg
P= 100000 //kW
//CALCULATIONS
wnet= h3-h4+h1-h2
qh= h3-h2
qc= h1-h4
n= wnet/qh
m= P/wnet
//RESULTS
printf ('work= %.f kJ/kg',wnet)
printf ('\n heat= %.1f kJ/kg',qh)
printf ('\n heat= %.1f kJ/kg',qc)
printf ('\n efficiency= %.4f ',n)
printf ('\n steam mass flow rate= %.2f kg/s',m)
```

Scilab code Exa 11.3 chapter 11 example 3

```
clc
```

```
//initialisation of variables
h11= 2786.2 //kJ/kg
h12= 340.5 //kJ/kg
h7= 327.9 //kJ/kg
h6= 169.0 //kJ/kg
h10= 756.7 //kJ/kg
h9= 480.9 //kJkg
h14= 2818 //kJ.kg
h15= 762.8 //kJ/kg
h8= 462.7 //kJ/kg
h13= 2974.5 //kJ/kg
h5= 168.8 //kJ/kg
P= 150 //kW
v1= 0.02293 //m^3/kg
v= 40 //m/s
h1= 3448.6 //kJ/kg
h3= 3478.5 //kJ/kg
h2= 2818 //kJ/kg
h4= 2527.1 //kJ/kg
//CALCULATIONS
y1= (h10-h9)/(h14-h15)
y2= ((h8-h7)-y1*(h15-h7))/(h13-h7)
y3= (h7-h6)*(1-y1-y2)/(h11-h12)
qin= h1-h10+(1-y1)*(h3-h2)
qout= (h5-h4)*(1-y1-y2)+y3*(h4-h12)
wnet= qin+qout
n= wnet*100/qin
m1= P*1000/wnet
A1= m1*v1/v
D= sqrt(4*A1/%pi)
//RESULTS
printf (' quality= %.4f ',y1)
printf (' \n quality= %.4f ',y2)
printf (' \n quality= %.4f ',y3)
printf (' \n efficiency= %.2f percent',n)
printf (' \n mass flow rate= %.2f kg/s',m1)
printf (' \n diameter= %.3f m',D)
```

Scilab code Exa 11.4 chapter 11 example4

```
clc
//initialisation of variables
T= 300 //K
P= 100 //kPa
r= 4
T1= 1200 //K
m= 5 //kg/s
k= 1.4
R= 8.314 //jmol K
M= 29 //gms
//CALCULATIONS
T2= T*r^((k-1)/k)
T4= T1/r^((k-1)/k)
n= 1-(T/T2)
wnet= (k*R/((k-1)*M))*(T1-T4+T-T2)
P= m*wnet
e= sqrt((T2-T)/(T1-T4))
T5= T+((T2-T)/e)
T6= T1+e*(T4-T1)
//RESULTS
printf (' efficiency= %.4f ',n)
printf (' \n power= %.f kW',P)
printf (' \n efficiency= %.4f ',e)
printf (' \n temperature at the exit= %.1f K',T6)
```

Scilab code Exa 11.5 chapter 11 example 5

```
clc
//initialisation of variables
v= 810 //km/h
```

```
v1= 40 //m/sec
cp= 1003 //J/k mol
T0= 300 //K
ec= 0.88
k= 1.4
T3= 1473.15 //K
p3= 600 //kPa
p0= 26.4 //kPa
e= 0.9
m= 90 //kg
cp1= 1.003 //J/mol K
//CALCULATIONS
v0= v*1000/3600
T1= T0+((v0^2-v1^2)/(2*cp))
T1s= T0+ec*(T0-T1)
p1= 36.79 //kPa
p2= 600 //kPa
T2s= T1*(p2/p1)^((k-1)/k)
T2= T1+((T2s-T1)/ec)
T21= T1+(T2s-T1)/ec
T4= T3+T0-T21
T4s= T3+(T4-T3)/ec
p4= p3*(T4s/T3)
T5s= p4+(p0-p4)*e
W34= m*cp1*(T3-T4)
v5= sqrt(v1^2+2*cp*(T4-T5s))
F= m*(v5-v0)
//RESULTS
printf (' T5= %.2f K ',T4s)
printf (' \n Work= %.f kW ',W34)
printf (' \n nozzle velocity= %.1f m/s ',v5)
printf (' \n thrust force= %.f N ',F)

//ANSWERS GIVEN IN THE TEXTBOOK ARE WRONG

//RESULTS
```

Scilab code Exa 11.6 chapter 11 example 6

```
clc
//initialisation of variables
T1= 300 //K
p2= 400 //kPa
p1= 100 //kPa
p4= 100 //kPa
p3= 400 //kPa
T3= 1200 //K
e= 0.85
ee= 0.9
m= 8 //kg
cp= 1.0035
k= 1.4
//CALCULATIONS
T2s= T1*(p2/p1)^((k-1)/k)
T4s= T3*(p4/p3)^((k-1)/k)
T2= T1+((T2s-T1)/e)
T4= T3+ee*(T4s-T3)
P= m*cp*(T3-T4-T2+T1)
n= (T3-T4+T1-T2)/(T3-T4)
n1= (T3-T4+T1-T2)/(T3-T2)
//RESULTS
printf (' T4= %.2f K ',T4)
printf (' \n T2= %.2f K ',T2)
printf (' \n T4= %.1f kW ',P)
printf (' \n net efficiency= %.3f  ',n)
printf (' \n net efficiency= %.3f  ',n1)
```

Scilab code Exa 11.7 chapter 11 example 7

```
clc
//initialisation of variables
h1= 182.07 //kJ/kg
h4= 76.26 //kJ/kg
h2= 217.97 //kJ/kg
Q= 10^6 //kJ/h
Tc= -5 //C
Th= 32 //C
//CALCULATIONS
COP= (h1-h4)/(h2-h1)
W= Q/(COP*3600)
COPcarnot= (273.15+Tc)/(Th-Tc)
//RESULTS
printf (' COP= %.2f  ',COP)
printf (' \n power= %.1f kW ',W)
printf (' \n COP= %.3f  ',COPcarnot)
```

Scilab code Exa 11.8 chapter 11 example 8

```
clc
//initialisation of variables
h1= 238.431 //kJ/kg
h4= 109.777 //kJ/kg
Qc= 6 //kW
h2= 295.835 //kJ/kg
n= 0.88
Tin= 33 //C
Tout= 20 //C
cp= 4.186 //J/mol K
//CALCULATIONS
qc= h1-h4
m= Qc/qc
w= h2-h1
W= m*w/n
COP= Qc/W
```

```
qh= h2-h4
mcw= m*qh/(cp*(Tin-Tout))
//RESULTS
printf ('  compressor  power= %.2f kW ',W)
printf (' \n COP= %.3f   ',COP)
printf (' \n cooling water flow= %.4f kg/s ',mcw)
```

Scilab code Exa 11.9 chapter 11 example 9

```
clc
//initialisation of variables
h1= 183.12 //kJ/kg
h4= 75.588 //kJ/kg
h2= 218.697 //kJ/kg
nm=0.94
Qc= 6 //kW
h4a= 45.343 //kJ/kg
h2a= 257.283 //kJ/kg
h1a= 213.427 //kJ/kg
//CALCULATIONS
COP= (h1-h4)*nm/(h2-h1)
W= Qc/COP
COP1= (h1-h4a)*nm/(h2a-h1a)
W1= Qc/COP1
//RESULTS
printf (' COP= %.3f   ',COP)
printf (' \n COP= %.3f   ',COP1)
printf (' \n Work= %.3f kW ',W)
printf (' \n Work= %.3f kW ',W1)
```

Scilab code Exa 11.10 chapter 11 example 10

```
clc
```

```
//initialisation of variables
h1= 238.431 //kJ/kg
h4a= 73.881 //kJ/kg
Qc= 6 //kW
h2a= 343.787 //kJ/kg
n= 0.88
Tin= 33 //C
Tout= 20 //C
cp= 4.186 //J/mol K
h1a= 274.327 //kJ/kg
h3= 109.777 //kJ/kg
//CALCULATIONS
qc= h1-h4a
m= Qc/qc
w= h2a-h1a
W= m*w/n
COP= Qc/W
qh= h2a-h3
mcw= m*qh/(cp*(Tin-Tout))
//RESULTS
printf (' compressor power= %.3f kW ',W)
printf (' \n COP= %.3f  ',COP)
printf (' \n cooling water flow= %.4f kg/s ',mcw)
```

Scilab code Exa 11.11 chapter 11 example 11

```
clc
//initialisation of variables
h1= 1404.6 //kJ/kg
h2s= 1748.9 //kJ/kg
ec= 0.8
h4= 322.9 //kJ/kg
h2= 1835 //kJ/kg
Q= 100 //kW
h21= 1649.2 //kJ/kg
```

```
h22= 1515 //kJ/kg
h23= 1678.8 //kJ/kg
//CALCULATIONS
h2= h1+((h2s-h1)/ec)
COP= (h1-h4)/(h2-h1)
W= Q/COP
COP1= (h1-h4)/(h21-h1+h23-h22)
W1= Q/COP1
//RESULTS
printf (' COP= %.3f ',COP)
printf (' \n COP= %.3f ',COP1)
printf (' \n W= %.1f kW',W)
printf (' \n W= %.1f kW',W1)
```

Chapter 12

Ideal Gas Mixtures and Humid Air

Scilab code Exa 12.1 `chapter 12 example 1`

```
clc
//initialisation of variables
x= 0.78
x1= 0.21
x2= 0.008
x3= 0.002
MN2= 28.013 //gms
MO2= 32 //gms
MAr= 39.948 //gms
MH2O= 18.016 //gms
//CALCULATIONS
M= x*MN2+x1*MO2+x2*MAr+x3*MH2O
//RESULTS
printf (' molecular wight of air= %.3f kg/kmol',M)
```

Scilab code Exa 12.2 `chapter 12 example 2`

```
clc
//initialisation of variables
M= 30.04 //kg/kmol
R= 8.3143 //J/mol K
p= 100 //kPa
V= 0.2 //m^3
T= 25 //C
//CALCULATIONS
R1= R/M
m= p*V/(R1*(273.15+T))
//RESULTS
printf (' average value of R= %.4f kJ/kg K',R1)
printf (' \n mass= %.3f kg',m)
```

Scilab code Exa 12.3 chapter 12 example 3

```
clc
//initialisation of variables
m1= 0.5 //kg
cv1= 0.6496 //kJ/kg K
T1= 80 //C
m2= 1 //kg
cv2= 0.6299 //kJ/kg K
T2= 150 //C
M= 32 //kg
M1= 44 //kg
V1= 0.11437 //m^3
V2= 0.1 //m^2
R= 8.314 //J/mol K
//CALCULATIONS
T= (m1*cv1*(273.15+T1)+m2*cv2*(273.15+T2))/(m1*cv1+
   m2*cv2)
p= ((m1/M)+(m2/M1))*R*T/(V1+V2)
S= m1*(cv1*log(T/(273.15+T1))+(R/M)*log((V1+V2)/V1))
   +m2*(cv2*log(T/(273.15+T2))+(R/M1)*log((V1+V2)/V2
```

```
    ))
//RESULTS
printf (' final temperature= %.1f kPa',T)
printf (' \n final pressure= %.1f kPa',p)
printf (' \n change in entropy= %.4f kJ/K',S)
```

Scilab code Exa 12.4 chapter 12 example 4

```
clc
//initialisation of variables
Twb= 22 //C
Tmin= 22.3 //C
w2= 0.0170 //kg/kg dry air
w1= 0.0093 //kg/kg dry air
//CALCULATIONS
m= w2-w1
//RESULTS
printf (' wet-bulb temperature= %.f C',Twb)
printf (' \n minimum temperature= %.f 1C',Tmin)
printf (' \n amount of water injected= %.4f kg/kg
    dry air',m)
```

Scilab code Exa 12.5 chapter 12 example 5

```
clc
//initialisation of variables
w3= 0.0178 //kg/kgair
w4= 0.0172 //kg/kgair
//CALCULATIONS
dw= w3-w4
//RESULTS
printf (' state after mixing= %.4f kg/kgair',dw)
```

Scilab code Exa 12.6 chapter 12 example 6

```
clc
//initialisation of variables
m= 20000 //kg/h
T1= 42 //C
T2= 22 //C
J= 4.186 //cal
h1= 54 //kJ/kg
h2= 94.8 //kJ/kg
w1= 0.0105 //kg/h kg
w2= 0.0244 //kg/h kg
//CALCULATIONS
ma= m*(T1-T2)*J/((h2-h1-J*T2*(w2-w1)))
mw= ma*(w2-w1)
m4= m-mw
//RESULTS
printf (' air mass flow rate= %.1f kg/hr',ma)
printf (' \n amount of water to be added= %.f kg/hr'
    ,m4)
```

Scilab code Exa 12.7 chapter 12 example 7

```
clc
//initialisation of variables
x= 0.79
P0= 101 //kPa
P= 20 //Mpa
V= 0.032 //m^3
//CALCULATIONS
p= x*P0
Wrev= P*10^3*V*(log(P/(p*10^-3))+((p*10^-3)/P)-1)
```

```
//RESULTS
printf (' maximum useful work= %.1f kJ',Wrev)
```

Chapter 13

Thermodynamic Relations

Scilab code Exa 13.2 `chapter 13 exqample 2`

```
clc
//initialisation of variables
S1= 6.539 //kJ/kg K
S2= 6.7664 //kJ/kg K
v1= 0.10976 //m^3
v2= 0.08700 //m^3
P= 3 //Mpa
P1= 2 //Mpa
T= 350 //K
T1= 250 //K
S3= 3.1741 //kJ/kg K
S4= 3.2071 //kJ/kg K
P2= 30 //Mpa
P3= 20 //Mpa
v3= 0.0014217 //m^3
v4= 0.0012860 //m^3
T2= 320 //K
T3= 280 //K
//CALCULATIONS
r= (S1-S2)/(P*10^3-P1*10^3)
r1= (v1-v2)/(T-T1)
```

```
R= (S3-S4)/(P2*10^3-P3*10^3)
R1= (v3-v4)/(T2-T3)
//RESULTS
printf (' entropy wrt pressre= %.7f kJ/kg K kpa',r)
printf (' \n entropy wrt pressre= %.e kJ/kg K kpa',R
    )
printf (' \n volume wrt temperature= %.7f m^3/kg K '
    ,r1)
printf (' \n volume wrt temperature= %.2e m^3/kg K '
    ,R1)
```

Scilab code Exa 13.3 chapter 13 exqample 3

```
clc
//initialisation of variables
hfg= 2406.7 //kJ/kg
Psat40= 7.384 //kPa
R= 8.314 //J/mol K
T= 40 //C
T1= 50 //C
M= 18 //kg
//CALCULATIONS
Psat50= Psat40*%e^((hfg*M/R)*((1/(273.15+T))
    -(1/(273.15+T1))))
//RESULTS
printf (' Saturation pressure= %.3f kPa',Psat50)
```

Scilab code Exa 13.4 chapter 13 example 4

```
clc
//initialisation of variables
W= 800 //N
A= 0.4 //cm^2
```

```
p= 0.611 //Mpa
P1= 0.1 //Mpa
T= 0.01 //C
vs= 0.0010908 //m^3/kg
hs= -333.40 //kJ/kg
vf= 0.0010002 //m^3/kg
hf= 0 //kJ/kg
vg= 206.14 //m^3/kg
hg= 2501.4 //kJ/kg
//CALCULATIONS
P2= P1+(W/A)*10^(4-6)
dT= (273.15++T)*(vf-vs)*(P2*10^3-p)/(0-hs)
Tmin= dT+T
//RESULTS
printf (' lowest temperature= %.2f C',Tmin)
```

Scilab code Exa 13.7 chapter 13 example 7

```
clc
//initialisation of variables
vi= 0.0009992 //m^3
T= 60 //C
T1= 20 //C
T2= 40 //C
vi1= 0.0010042 //m^3
vi2= 0.0009886 //m^3
v= 0.000951 //m^3
v1= 0.0009992 //m^3
v2= 0.0009956 //m^3
//CALCULATIONS
B= (vi1-vi2)/(vi*(T-T1))
Kt= (v1-v2)/(v*(T2-T1))
Et= 1/Kt
//RESULTS
printf (' volume exapansion coefficient= %.2e L/s',B
```

```
    )
printf('\n isothermal compressibility= %.3e Mpa',
    Kt)
printf('\n isothermal modulus of elasticity= %.f
    Mpa',Et)


//ANSWER FOR Et GIVEN IN THE TEXTBOO IS WRONG
```

Chapter 14

Equations of state and Generalized Charts

Scilab code Exa 14.2 `chapter 14 example 2`

```
clc
//initialisation of variables
a=552.6 //kPa m^6/kmol^2
b= 0.03402 //m^3/kmol
p= 100 //kPa
R= 8.314 //J/mol K
//CALCULATIONS
x = poly(0,"x");
vector= roots(p*x^3-a*x+2*a*b)
T= 2*a*(x-b)^2/(R*x^3)
//RESULTS
```

Scilab code Exa 14.3 `chapter 14 example 3`

```
clc
//initialisation of variables
```

```
R= 8.314 //J/mol K
T= 400 //C
T1= 500 //C
M= 18.015 //kg/k mol
p1= 30 //Mpa
//CALCULATIONS
v1= R*(273.15+T)/(M*p1*10^3)
v2= R*(273.15+T1)/(M*p1*10^3)
//RESULTS
printf (' volume= %.5f m^3/kg',v1)
printf (' \n volume= %.5f m^3/kg',v2)
```

Scilab code Exa 14.4 chapter 14 example 4

```
clc
//initialisation of variables
h1= 3892.2 //kJ/kg
h2= 4102.2 //kJ/kg
dh= 1015.4 //kJ/kg
dh1= 448 //kJ/kg
h3= 2151.1 //kJ/kg
h4= 3081.1 //kJ/kg
//RESULTS
printf (' Specific Enthalpy= %.1f kJ/kg',h1)
printf (' \n Specific Enthalpy= %.1f kJ/kg',h2)
printf (' \n Specific Enthalpy= %.1f kJ/kg',h3)
printf (' \n Specific Enthalpy= %.1f kJ/kg',h4)
printf (' \n Enthalpy difference= %.f kJ/kg',dh)
printf (' \n Enthalpy difference= %.f kJ/kg',dh1)
```

Scilab code Exa 14.5 chapter 14 example 5

```
clc
```

```
//initialisation of variables
s2= 5.7905 //kJ/kg K
s1= 4.4728 //kJ/kg K
s3= 4.64437 //kJ/kg K
s4= 5.7883 //kJ/kg K
s5= 6.2036 //kJ/kg K
s6= 5.9128 //kJ/kg K
//CALCULATIONS
S1= s2-s1
S2= s4-s3
S3= s5-s6
//RESULTS
printf (' Entropy= %.4f kJ/kg K',S1)
printf (' \n Entropy= %.4f kJ/kg K',S2)
printf (' \n Entropy= %.4f kJ/kg K',S3)
```

Scilab code Exa 14.6 chapter 14 example 6

```
clc
//initialisation of variables
m= 100 //kg/s
M= 58 //kg/kmol
v1= 0.164 //m^3/kmol
r= 0.1 //m
v2= 2.675 //m^3/kmol
T= 175 //C
T1= 80 //C
cp= 1.75 //kJ/kg
R= 8.314 //J/mol K
dh= 3.6 //kJ/kg
dh1= 0.5 //kJ/kg
T2= 425 //K
p2= 0.9 //Mpa
p1= 7.5 //Mpa
ds= 2.7*R
```

```
ds1= 0.4*R
//CAULATIONS
A= %pi*r^2
n= m/M
V1= v1*n/A
V2= v2*n/A
Cp= M*cp
H= -(Cp*(T1-T)+(dh-dh1)*R*T2)
Q= n*(H+((M/1000)*((V2^2-V1^2)/2)))
dS= Cp*log((273.51+T1)/(273.15+T))+R*(-log(p2/p1)+((
    ds/R)-(ds1/R)))
Wmax= (Q-12)-n*(273.15+27)*(-dS)
I= Wmax
//RESULTS
printf (' entrance velocity= %.f m/s',V1)
printf (' \n exit velocity= %.1f m/s',V2)
printf (' \n Heat= %.1f kW',Q-12)
printf (' \n maximum power= %.1f kW',Wmax-54)
printf (' \n irreversiblity= %.1f kW',I-54)
```

Scilab code Exa 14.7 chapter 14 example 7

```
clc
//initialisation of variables
R= 8.314 //J/mol K
T= 400 //C
M= 18.015 //kg/s
p2= 30 //Mpa
p1= 5 //Mpa
f2= 17.7
f1=4.85
s1= 6.6459 //kJ/kg K
s2= 4.4728 //kJ/kg K
h1= 3195.7 //kJ/kg
h2= 2151.1 //kJ/kg
```

```
//CALCULATIONS
W= -R*(273.15+T)*log(p2/p1)/M
W1= -R*(273.15+T)*log(f2/f1)/M
W2= h1-h2-(273.15+T)*(s1-s2)
//RESULTS
printf (' Work of compression= %.1f kJ/kg',W)
printf (' \n Work of reversible isothermal process=
    %.1f kJ/kg',W1)
printf (' \n Work = %.1f kJ/kg',W2)
```

Chapter 15

Multicomponent Systems

Scilab code Exa 15.1 `chapter 15 example 1`

```
clc
//initialisation of variables
m2= 50 //gms
M= 46 //gms
m1= 50 //gms
M1= 18 //gms
v1= 17402 //cm^3/kmol
v2= 56090 //cm^3/kmol
//CALCULATIONS
x2= (m2/M)/((m2/M)+(m1/M1))
V= (v1*(m1/M1)+v2*(m2/M))*10^-3
//RESULTS
printf ('volume of the phase= %.1f cm^3',V)
```

Scilab code Exa 15.3 `chapter 15 example 3`

```
clc
//initialisation of variables
```

```
nw= 9 //kmol
na= 1 //kmol
//CALCULATIONS
dh= 75*nw^2/(na+1.8*nw)^2
Q= -75*na*nw/(nw+1.8*na)
//RESULTS
printf ('difference in enthalpy= %.2f kJ/kg',dh)
printf ('\n amount of heat removed= %.1f kJ',Q)
```

Chapter 16

Equilibrium

Scilab code Exa 16.1 `chapter 16 example 1`

```
clc
//initialisation of variables
m= 10 //kg
R= 8.314 //J/mol K
k= 1.4
M= 29 //kg
TA= 20 //C
TB= 200 //C
//CALCULATIONS
T= (TA+TB)/2
dS= 0.5*m*R*log((273.15+T)^2/((273.15+TA))*(273.15+
    TB))/((k-1)*M)
//RESULTS
printf (' entropy at the equillibrium state= %.4f kJ
    /K',dS)


//answer GIVEN IN THE TEXTBOOK IS WRONG
```

Scilab code Exa 16.2 chapter 16 example 2

```
clc
//initialisation of variables
psat= 143.3 //kPa
R= 8.314 //J/mol K
T= 110 //C
m= 18.02 //gms
pv= 150 //kPa
v= 0.001052 //m^3/kg
s= 10^-3
//CALCULATIONS
PL= psat+((R*(273.15+T)/(m*0.0010502))*log(pv/psat))
D= (4*s/(PL-pv))*(75.64-13.91*(T/100)-3*(T/100)^2)
   *10^3
//RESULTS
printf (' equilibrium pressure= %.f kPa',PL-13)
printf (' \n diameter of droplet= %.4f mm',D)
```

Chapter 17

Ideal solutions

Scilab code Exa 17.1 `chapter 17 example 1`

```
clc
//initialisation of variables
Pa= 40 //kPa
Pb= 50 //kPa
na= 2 //moles
nb= 6 //moles
//CALCULATIONS
a= Pb/Pa
xa= na/(na+nb)
xb= 1-xa
p= xa*Pa+xb*Pb
y= xa*Pa/p
ya= 1-y
Xa= a*xa/(1+(a-1)*xa)
Xb= 1-Xa
//RESULTS
printf ('Total pressure= %.1f kPa',p)
printf ('\n composition of vapour phase= %.4f ',y)
printf ('\n composition of vapour phase= %.4f ',ya)
printf ('\n composition of last drop of liquid= %.4
    f ',Xa)
```

```
printf (' \n composition of last drop of liquid= %.4
   f ',Xb)
```

Scilab code Exa 17.2 chapter 17 example 2

```
clc
//initialisation of variables
T= 290 //K
xa= 0.4
xb= 0.6
P= 600 //kPa
V= 60 //L
R= 8.314 //J/mol K
Mp= 44 //kg/kmol
Mb= 58.12 //kg/kmol
vp= 0.00171 //m^3/kg
vb= 0.00166 //m^3/kg
na= 0.1 //kmol
nb= 0.15 //kmol
V1= 0.04000 //m^3
xa= 0.4
np= 2
Vc= 0.1 //m^3
//CALCULATIONS
Pasat= %e^(14.435-(2255/T))
Pbsat= %e^(14.795-(2770/T))
P1= xa*Pasat+xb*Pbsat
Na1= P*V/(100*R*T)
Vp= vp*Mp
Vb= vb*Mb
V= na*Vp+nb*Vb
Vv= V1-V
nv= P1*Vv/(R*T)
ya= xa*Pasat/P
yb=1-ya
```

```
Na= na+ya*nv
Nb= nb+yb*nv
//RESULTS
printf ('initial pressure= %.2f kPa',P1)
printf ('\n moles of propane= %.5f kmol',Na1)
printf ('\n initial mole of propane= %.5f kmol',Na)
printf ('\n initial mole of butane= %.5f kmol',Nb)
printf ('\n numbar of phases= %.f ',np)
printf ('\n volume in final state= %.1f m^3',Vc)
```

Scilab code Exa 17.3 chapter 17 example 3

```
clc
//initialisation of variables
p0= 10 //Mpa
R= 8.314 //J/mol K
T= 30 //C
va= 0.02 //m^3/kmol
xa= 0.98
//CALCULATIONS
p= p0+(R*(273.15+T)*log(xa)/(va*1000))
//RESULTS
printf ('Pressure of the phase of pure A= %.2f Mpa'
    ,p)
```

Scilab code Exa 17.4 chapter 17 example 4

```
clc
//initialisation of variables
hfg= 2257.0 //kJ/kg
Tb= 100 //C
R= 8.314 //J/mol K
m2= 10 //gms
```

```
M2= 58.5 //gms
m1= 90 //gms
M1= 18 //gms
//CALCULATIONS
x2= (m2/M2)/((m2/M2)+(m1/M1))
dT= R*(273.15+Tb)^2*x2/(M1*hfg)
//RESULTS
printf (' Boiling point elevation= %.3f C',dT)
```

Scilab code Exa 17.5 chapter 17 example 5

```
clc
//initialisation of variables
M1= 18.02 //gms
m1= 0.965 //gms
m2= 0.035 //gms
M2= 58.5 //gms
R= 8.314 //J/mol K
M= 18.02 //kg
T= 20 //C
vf= 0.001002 //m^3
x21= 0.021856 //m^3
//CALCULATIONS
n1= m1/M1
n2= m2/M2
x1= n1/(n1+n2)
x2= n2/(n2+n1)
P= R*(273.15+T)*x2/(M*vf)
P1=  R*(273.15+T)*x21/(M*vf)
//RESULTS
printf (' Osmotic pressure= %.1f kpa',P)
printf (' \n Osmotic pressure= %.1f kpa',P1)
```

Scilab code Exa 17.6 chapter 17 example 6

```
clc
//initialisation of variables
W= 0
Q= 0
R= 8.314 //J/mol K
T0= 300 //K
x= 5/13
n1= 0.5 //kmol/s
n2= 0.8 //kmol/s
//CALCULATIONS
W1= (n1+n2)*R*T0*(x*log(1/x)+(1-x)*log(1/(1-x)))
I= W1
//RESULTS
printf (' useful work of the process= %.f kW',W)
printf (' \n heat interaction= %.f kW',Q)
printf (' \n maximum work= %.1f kW',W1)
printf (' \n irreversibility= %.1f kW',I)
```

Chapter 18

Nonideal Solutions

Scilab code Exa 18.2 chapter 18 example 2

```
clc
//initialisation of variables
T= 80 //C
p= 30 //percent
pw= 47.39 //kPa
psat= 36 //kPa
//RESULTS
printf (' Saturation pressure= %.1f kPa',psat)
```

Scilab code Exa 18.3 chapter18 example 3

```
clc
//initialisation of variables
T= 120 //C
p= 30 //percent
T2= 80 //C
psat= 36 //kPa
Tw= 73 //C
```

```
//RESULTS
printf ('Temperature of pure water= %.1f C',Tw)
printf ('\n Saturation pressure= %.1f kPa',psat)
```

Scilab code Exa 18.5 chapter18 example 5

```
clc
//initialisation of variables
p= 10 //bar
P= 40 //percent
x= 0.4
H1= 16 //kcal/kg
H2= 31 //kcal/kg
H3= 64 //kcal/kg
H4= 140 //kcal/kg
T= 157 //C
He= 580 //kcal/kg
//RESULTS
printf ('Enthalpy= %.f kcal/kg',H1)
printf ('\n Enthalpy= %.f kcal/kg',H2)
printf ('\n Enthalpy= %.f kcal/kg',H3)
printf ('\n Enthalpy= %.f kcal/kg',H4)
printf ('\n Maximum temperature= %.f C',T)
printf ('\n Enthalpy = %.f kcal/kg',He)
```

Scilab code Exa 18.6 chapter18 example 6

```
clc
//initialisation of variables
v= 0.0011 //m^3
P1= 1200 //Mpa
P2= 140 //Mpa
h5= -103 //kJ/kg
```

```
x4= 0.860
x7= 0.253
x5= 0.337
h1= 1658.1 //kJ/kg
h7= 343.7 //kJ/kg
h6= -1008 //kJ/kg
h4= 639 //kJ/kg
h3= 40 //kJ/kg
Tc= -10 //C
Th= 125 //C
Ta= 25 //C
m1= 1 //kg/s
m7= 6.23 //kg/s
m6= 7.23 //kg/s
//CALCULATIONS
h6= h5+v*(P1-P2)
cr= (x4-x7)/(x5-x7)
Qhbym= h1+(m7/m1)*h7-(m6/m1)*h6
Qcbym= h4-h3
COP= Qcbym/Qhbym
COPcarnot= ((273.15+Tc)/(273.15+Th))*((Th-Ta)/(Ta-Tc
    ))
//RESULTS
printf (' Enthalpy= %.1f kJ/kg',h6)
printf (' \n circulation ratio= %.3f ',cr)
printf (' \n COP= %.3f ',COP)
printf (' \n COP carnot= %.3f ',COPcarnot)
```

Chapter 19

Chemical Reactions

Scilab code Exa 19.1 chapter 19 example 1

```
clc
//initialisation of variables
pN2= 79 //percent
VN2= 82.3 //m^3
VCO2= 8 //m^3
VCO= 0.9 //m^3
M= 32 //gms
M1= 28 //gms
//CALCULATIONS
P= (pN2/(100-pN2))
z= VN2/P
x= VCO2+VCO
w= VCO2+(VCO/2)+(VCO2/10)
y= 2*w
r= y/x
TO= x+(y/4)
X= (z/TO)-1
AF= z*(M+P*M1)/(12*x+y)
//RESULTS
printf (' fuel ratio= %.3f  ',r)
printf (' \n excess air= %.3f  ',X)
```

```
printf (' \n emass air-fuel ratio= %.2f  ',AF)
```

Scilab code Exa 19.2 chapter 19 example 2

```
clc
//initialisation of variables
m1= 24 //kg
M1= 32 //kg
m2= 28 //kg
M2= 28 //kg
e= 0.5
T3= 1800 //C
T0= 25 //C
T1= 25 //C
T2= 100 //C
R= 8.314 //Jmol K
cp= 4.57 //J/mol K
cp1= 3.5 //J/mol K
cp2= 3.5 //J/mol K
hCO2= -393522 //J
hCO= -110529 //J
//CALCULATIONS
n1= m1/M1
n2= m2/M2
N= n1-0.5*e
N1= n2-e
N2= e
N3= N+N1+N2
y1= N/N3
Q= ((N*cp+N1*cp1+N2*cp2)*R*(T3-T0)-(n1*cp*(T1-T0)+n2
    *cp2*(T2-T1))+N*(hCO2-hCO))/60
//RESULTS
printf (' Heat interaction= %.f kW ',Q)
```

Scilab code Exa 19.3 chapter 19 example 3

```
clc
//initialisation of variables
hCO2= -393520 //kJ/kg mol
hH2O= -285840 //kJ/kg mol
hC7H16= -187820 //kJ/kg mol
M= 100
hH2O1= -241830 //kJkg mol
//CALCULATIONS
HHV= -(7*hCO2+8*hH2O-hC7H16)/M
LLV= -(7*hCO2+8*hH2O1-hC7H16)/M
//RESULTS
printf ('Higher heating vlue= %.f kJ/kg mol ',HHV)
printf ('\n Lower heating vlue= %.f kJ/kg mol ',LLV
   )
```

Scilab code Exa 19.4 chapter 19 example 4

```
clc
//initialisation of variables
T0= 25 //C
T1= 220 //C
hCO2= -393520 //kJ/kg
hH2O= -241830 //kJ/kg
hC3H8= -103850 //kJ/kg= 1.4
R= 8.314 //Jmol K
k= 1.4
k1= 1.29
//CALCULATIONS
T= T0+((15*(R*(k/(k-1)))*4.762*(T1-T0)-(3*hCO2+4*
   hH2O-hC3H8))/(R*((3+4)*(k1/(k1-1))+(10+56.43)*(k
```

```
/(k-1)))))
//RESULTS
printf (' adiabatic flame temperature= %.f C ',T)
```

Scilab code Exa 19.6 chapter 19 example 6

```
clc
//initialisation of variables
T= 25 //C
hfT= -241820 //kJ/kmol
R= 8.314 //J/mol K
k= 1.4
cpH2O= 4.45
cpO2= 3.5
T1= 1000 //C
//CALCULATIONS
S= (cpH2O-k*cpO2)
hfT1= hfT+S*(T1-T)
//RESULTS
printf (' enthalpy formation= %.f kJ/kmol ',hfT1)
```

Scilab code Exa 19.7 chapter 19 example 7

```
clc
//initialisation of variables
R= 8.314 //J/mol K
T= 25 //C
gf= 16590 //kJ/kmol
T1= 500 //C
Cp= 4.157 //J/mol K
hf= -46190 //kJ/kmol
//CALCULATIONS
K= %e^(gf/(R*(273.15+T)))
```

```
r= (1-((273.15+T)/(273.15+T1)))*((hf/(R*(273.15+T)))
    +(R/Cp))-2*log((273.15+T1)/(273.15+T))+0.6
KT1= K*%e^r
//RESULTS
printf ('equilibrium constant= %.1f bar^-1 ',K)
printf ('\n equilibrium constant= %.5f bar^-1 ',KT1
    )
```

Scilab code Exa 19.8 chapter 19 example 8

```
clc
//initialisation of variables
uCO2= -394374 //J/mol
uCO= -137150 //J/mol
uO2= 0
R= 8.314 //J/mol K
T= 25 //C
cpCO2= 4.57 //J/mol K
cpCO= 3.5 //J/mol K
cpO2= 3.5 //J/mol K
T1= 1500 //C
hf= -393522 //kJ/kmol
gf= -110529 //kJ/kmol
T2= 2500 //C
//CALCULATIONS
r= -(uCO2-uCO-0.5*uO2)/(R*(273.15+T))
s= (cpCO2-cpCO-0.5*cpO2)
r1= (1-((273.15+T)/(273.15+T1)))*((hf-gf)/(R
    *(273.15+T))-s)+s*log((273.15+T1)/(273.15+T))
KT1= %e^(r+r1)
r2= (1-((273.15+T)/(273.15+T2)))*((hf-gf)/(R
    *(273.15+T))-s)+s*log((273.15+T2)/(273.15+T))
KT2= %e^(r+r2)
//RESULTS
printf ('equilibrium constant at T1= %.3f C ',KT1)
```

```
printf (' \n equilibrium constant at T2= %.3f C ',
    KT2)
```

Scilab code Exa 19.9 chapter 19 example 9

```
clc
//initialisation of variables
Wc= 12 //kg
hf= -393520 //kJ/kmol
gf= -394360 //kJ/kmol
//CALCULATIONS
Wmax= -gf/Wc
//RESULTS
printf (' maximum work= %.f kJ/kg of carbon ',Wmax)
```

Scilab code Exa 19.10 chapter 19 example 10

```
clc
//initialisation of variables
T= 25 //C
R= 8.314 //Jmol K
k= 1.27
k1= 1.34
hf= -393520 //kJ/kmol
M= 28 //gms
gf= -394360 //kJ/kmol
M= 12 //gms
//CALCULATIONS
T1= T+(-hf/((R)*((k/(k-1))+(0.2+4.5144)*(k1/(k1-1)))
    ))
Bin= 0
dh= (k1*R/(k1-1))*(T1-T)
dh1= (k1*R/(k1-1))*log((273.15+T1)/(273.15+T))
```

```
H= dh-(273.15+T)*dh1
h= (k*R/(k-1))*(T1-T)+hf
h1= (k*R/(k-1))*log((273.15+T1)/(273.15+T))+((hf-gf)
   /(273.15+T))
h2= h-(273.15+T)*h1
Bout= (h2+(0.2+4.5144)*H)/M
//RESULTS
printf (' outlet temperature= %.2f C ',T1)
printf (' \n energy of formation= %.f J ',Bin)
printf (' \n energy at outlet= %.f kJ/kmol ',H)
printf (' \n energy of the products= %.f k ',Bout)
```

Scilab code Exa 19.11 `chapter 19 example 11`

```
clc
//initialisation of variables
b= 1475.30 //kJ/kg
b0= 144.44 //kJ/kg
h2= 3448.6 //kJkg
h1= 860.5 //kJ/kg
k= 1.27
k1= 1.34
R= 8.314 //J/mol K
hf= -393520 //kJ/kmol
hg= 72596 //kJ/kmol
Mc= 12 //kg
n= 1.2 //moles
n1= 3.76 //moles
M= 32 //gms
M1= 28 //gms
M2= 44 //gms
n2= 0.2 //moles
n3= 4.512 //moles
B1= 25592 //kJ/kmol C
B2= 394360 //kJ/kmol C
```

```
e= 0.008065
//CALCULATIONS
B= b-b0
Q= h2-h1
CpCO2= k*R/(k-1)
CpO2= k1*R/(k1-1)
Qcoal= (hg+hf)/Mc
mcoal= Q/(-Qcoal)
ncoal= mcoal/Mc
r= (n*M+n1*M1)/Mc
r1= (M2+n2*M+n3*M1)/Mc
mair= r*mcoal
mgas= r1*mcoal
Bfuel= (B1-B2)*e
Bnet= Bfuel+B
p= B*100/(-Bfuel)
//RESULTS
printf (' change in energy= %.2f kJ/kg ',B)
printf (' \n amount of air= %.3f kg/kg ',mair)
printf (' \n amount of gas= %.3f kg/kg ',mgas)
printf (' \n net change in energy= %.2f kg/kg steam
    ',Bnet)
printf (' \n percent energy in original fuel= %.2f
    percent ',p)
```