Scilab Textbook Companion for Introduction to Materials Science for Engineers by J. F. Shackelford[1]

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Book Description

Title: Introduction to Materials Science for Engineers

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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 2

ATOMIC BONDING

Scilab code Exa 2.1 Calculate the numbers of atoms sampled in a 1 mewm diameter by

```
1 // Example 2.1//
2 d= 8.93;//g/cm^3 // density of copper
3 a=63.55;//amu // atomic mass of copper
4 //The volume sampled
5 c=1;//mew meter //deep cylinder in the surface of
     solid copper
6 e=2;//given
7 f=1;//cm //centimeter
8 g=10^4;//mew m
9 vs=(%pi*(c/e)^2)*(1/10^4)^3//Volume sampled formula
10 mprintf(" vs = %e cm^3",vs)
11 //Thus, the number of atoms sampled
12 a1=8.93;//g/cm^3
13 b=0.602*10^24;//atoms//Avogadro's number
14 c1=63.55;//g
15 ns=a1*vs*b/c1
16 mprintf("\n ns = %e atoms",ns)
```

Scilab code Exa 2.2 Calculate density of MgO

```
1 //Example 2.2//
2 a=24.31;//g //atomic mass of Mg (in gram)
3 a1=16.00;//g //atomic mass of O (in gram)
4 m=a+a1;// mass of 1 mol of MgO
5 mprintf("m = %f g ",m)
6 v=22.37;//mm //Volume
7 b=10^-3;//cm^3/mm^3
8 d=m/(v^3*b)
9 mprintf("\nd = %f g/cm^3",d)
```

Scilab code Exa 2.3 Calculate the dimension of a cube containing 1 mol of solid ma

```
1 //Example 2.3//
2 d= 1.74;// g/cm^3 //density of Mg
3 a= 24.31;//amu //atomic mass of Mg
4 v=a/d;// volume of 1 mol
5 mprintf("v = %f cm^3/mol",v)
6 c=10;//mm/cm
7 e= (v)^(1/3);//cm //edge of cube
8 //mprintf("\ne = %f cm",e)
9 e1=e*c
10 mprintf("\ne1 = %f mm",e1)
```

Scilab code Exa 2.5 What is repulsive force in this case

```
1 // Example 2.5//
2
3 rna=0.098;//nm // Ionic radius of Sodium (From
    appendix 2)
4 rcl=0.181;//nm // Ionic radius of Cholrine (From
    Appendix 2)
5 a0=rna+rcl
6 mprintf("a0 = %f nm",a0)
```

```
7  k0=9*10^9;//V m/C //Proportionality constant
8  z1=0.16*10^-18;//C //coloumb //valence of charged
      ion
9  z2=0.16*10^-18;//C //coloumb //valence of charged
      ion
10 q=1;// charge of single electron
11 q1=-1;//charge of single electron
12 a1=0.278*10^-9;//nm// separation distance between
      the centers of th ions
13 FC=-(k0*q*z1*q1*z2)/(a1^2)
14 mprintf("\nFC = %e N",FC)
15 // Nothing that 1V C=1J, we obtain
16
17 //(b) Because FC+FR =0
18 FR=-FC
19 mprintf("\nFR = %e N",FR)
```

Scilab code Exa 2.6 What is repulsive force in this case

```
1  //Example 2.6//
2  rNa=0.098//nm // Ionic radius of Sodium (From
      appendix 2)
3  rO=0.132//nm // // Ionic radius of Oxygen (From
      appendix 2)
4  a0=rNa+rO//nm
5  mprintf("a0 = %f nm",a0)
6  k0=9*10^9;//m/C // proportionality constant
7  q=1;//charge of single electron
8  z1=0.16*10^-18;//C //valence of the charged ions
9  z2=0.16*10^-18;//C //valence of the charged ions
10 q1=-2;//charge of single electron
11 a1=0.231*10^-9;//nm //separation distance between
      the centers of th ions
12 Fc=-(k0*q*z1*q1*z2)/(a1)^2
13 mprintf("\nFc = %e N",Fc)
```

```
14 Fr=-Fc
15 mprintf("\n Fr = %e N",Fr)
```

Scilab code Exa 2.7 Calculate the minimum radius ratio for a coordination number o

```
1 //Example 2.7//
2
3 a=sqrt(3);// Given //By formula
4 b=1;//Given
5 r=a-b
6 disp(r)
```

Scilab code Exa 2.8 Estimate the cordination number for the cation in each of thes

```
1 //Example2.8//
2 //From Appendix 2
3 rAl=0.057;//nm //Ionic radius of Aluminium
4 rB=0.02;//nm //Ionic radius of Boron
5 rCa=0.106;//nm //Ionic radius of Calcium
6 rMg=0.078;//nm// Ionic radius of Magnesium
7 rSi=0.039;//nm //Ionic radius of Silicon
8 rTi=0.064;//nm //Ionic radius of Titanium
9 rO=0.132//nm //Ionic radius of Oxygen
10 r=rAl/rO
11 mprintf("r = %f ",r)
12 //For B2O3
13 r1=rB/rO
14 mprintf("\nr1 = %f ,giving CN=2",r1)
15 //For CaO
16 r2=rCa/rO
17 mprintf("\nr2 = %f ,giving CN=8",r2)
18 //For MgO
19 r3=rMg/rO
```

```
20 mprintf("\nr3 = %f ,giving CN=6",r3)
21 //For SiO2
22 r4=rSi/r0
23 mprintf("\nr4 = %f ,giving CN=4",r4)
24 //For TiO2
25 r5=rTi/r0
26 mprintf("\nr5 = %f ,giving CN=6",r5)
27 mprintf("\nThe coordination number for the cation is
       obtain from Table 2.1")
```

Scilab code Exa 2.10 Calculate the reaction energy for the polymerization of polyv

```
1 //Example 2.10//
2 a=2;//Given
3 b=370;//kJ/mol //Bond energy
4 c=680;//kJ/mol //Bond energy
5 r=a*b
6 mprintf("r = %i kJ/mol",r)
7 re=r-c
8 mprintf("\nre = %i kJ/mol",re)
```

Scilab code Exa 2.12 Calculate the bond energy and bond length for argon

```
1 //Example 2.12//
2 kr=16.16*10^-135;// J m^12 //constant of attraction
3 ka=10.37*10^-78;//J m^6 //constant of replusion
4 a0=(2*(kr/ka))^(1/6)
5 mprintf("a0 = %e m = 0.382nm  (As 1 nano = 10^-9)",
     a0)
6 a1=0.382*10^-9;//meter
7 E=-(ka/a1^6)+(kr/a1^12)
8 mprintf("\nE = %e J",E)
9 a=-1.66*10^-21;//J/bond
```

```
10 b=(0.602*10^24);// bonds/mole
11 Eb=a*b
12 mprintf("\nEb = %e J/mol  = 0.999 kJ/mol (As 10^3
     gram = 1Kilogram)",Eb)
```

Chapter 3

Crystalline Structure Prefection

Scilab code Exa 3.2 Calculate density of copper

```
1 //Example 3.2//
2 rCu=0.128;//nm //atomic radius copper (From appendix
      2)
3 a=(4/sqrt(2))*rCu
4 mprintf("a = %f nm",a)
5 //The density of the unit cells is
6 a1=4;// atoms
7 b1=63.55;//gram //atomic mass of copper
8 c1=0.6023*10^24;//atoms// Avogardo's number
9 d=10^7;//nm/cm
10 p=(a1/a^3)*(b1/c1)*d^3
11 mprintf("\n p = %f g/cm^3",p)
```

Scilab code Exa 3.3 Calculate IPF of MgO

```
1 //Example 3.3//
```

```
2 rMg=0.078;//nm // Ionic radius of Magnesium (From
    Appendix 2)
3 rO=0.132;//nm // Ionic radius of Oxygen (From
    Appendix 2)
4 a=2*rMg+2*rO
5 mprintf("a = %f nm",a)
6 Vu=(a)^3;//nm
7 mprintf("\nVu = %f nm^3",Vu)
8 b=4;//by formula
9 c=4/3;//By formula
10 volume=((b*c)*%pi*(rMg)^3)+((b*c)*%pi*(rO)^3)
11 mprintf("\nvolume = %f nm^3",volume)
12 IPF=volume/Vu;
13 mprintf("\nIPF = %f ",IPF)
```

Scilab code Exa 3.4 Calculate density of MgO

```
1 //Example 3.4//
2 a=24.31;//gram //atomic mass of magnesium
3 b=16.00;//gram // atomic mass of oxygen
4 c=0.6023*10^24;//Avogardo's number
5 v=0.0741;//nm^3 //unit cell volume
6 d=10^7;//nm/cm
7 e=4;//Number of electrons
8 p=((((e*a)+(e*b))/(c))/(v))*d^3
9 mprintf("p = %f g/cm^3",p)
```

Scilab code Exa 3.5 Calculate number of C and H atoms in the polyethylene unit cel

```
1 //Example 3.5//
2 a=0.741;//nm //unit cell dimensions
3 b=0.494;//nm //unit cell dimensions
4 c=0.255;//nm //unit cell dimensions
```

```
v=a*b*c
mprintf("v = %f nm^3",v)
a1=12.01;//gram //atomic mass of carbon
b1=1.008;//gram // atomic mass of Hydogen
c1=0.6023*10^24;//atoms // Avogardo's number
d1=2;//Number of electrons
e1=4;//Number of electrons
m=((d1*a1)+(e1*b1))/c1
mprintf("\nm = (%e n)g",m)
//Therefore, the unit cell density is,
d=10^7;//nm/cm
p=(m/v)*d^3
mprintf("\n p = %f g/cm^3 (As answer in the textbook
    is calculated wrong)",p)
//solving for n gives
n=2
//Aa a result, there are
mprintf("\n4(=2n)C atoms + 8(=4n)H atoms per unit
   cell.")
```

Scilab code Exa 3.6 Calculate the APF for the diamond cubic structure

```
//Example 3.6//
a=2;//body diagonal
b=4;//body diagonal
c=a*b ;//(using cross multiplication)
//mprintf("c= %i ",c)
d=sqrt(3);
Vu=(c/d)^3
mprintf("Vu = %f rSi^3",Vu)
Va=c*(4/3)*%pi
mprintf("\n Va = %f rSi^3",Va)
APF=Va/Vu;
mprintf("\nAPF = %f ",APF)
```

Scilab code Exa 3.7 Calculate the density of silicon

```
1 //Example 3.7//
2 a=98.5;// Unit cell volume
3 b=0.117;//nm //nanometer //atomic radius of Silicon
4 V=a*b^3
5 mprintf("V = %f nm^3",V)
6 a1=8;//atoms
7 c=28.09;//gram //atomic mass of silicon
8 d=0.6023*10^24;//atoms //Avogardo's number
9 e=10^7;//nm/cm
10 P=(a1/V)*(c/d)*(e^3)
11 mprintf("\nP = %f g/cm^3",P)
```

Scilab code Exa 3.11 What is the angle between the 110 and 111 direction in the cu

```
1 //Example 3.11//
2 u=1;
3 u1=1;
4 v=1;
5 v1=1;
6 w=0;
7 w1=1;
8 a=(u*u1)+(v*v1)+(w*w1)
9 //mprintf("a = %i",a)
10 b=(sqrt((u^2)+(v^2)+(w^2)))*(sqrt((u1^2)+(v1^2)+(w1
    ^2)))
11 //mprintf("b = %i",b)
12 c=acosd(a/b)
13 mprintf("c = %f degree ",c)
```

Scilab code Exa 3.12 Identify the axial intercepts for the 311 plane

```
1 //Example 3.12//
2 //As the  problem  is in the statement in the book
3 mprintf("As the  problem  is in the statement in the
    book it cannot be solved using scilab")
```

Scilab code Exa 3.13 List the members of the 110 family of planes in the cubic sys

```
1 //Example 3.13//
2 //As the  problem  is in the statement in the book
3 mprintf("As the  problem  cannot be solved using
   scilab This problem is same as sample problem
   3.10 ")
```

Scilab code Exa 3.14 Calculate the linear density of atoms along the 111 direction

```
1 //Example 3.14 (a)//
2 a=2;//given
3 rw=0.137;//nm // atomic radius of Tungsten
4 r=a*rw
5 mprintf("r = %f nm",r)
6 r1=1/(r) //Taking inverse of r
7 mprintf("\nr1 = %f atoms/nm",r1)
8 //Example 3.14 (b)
9 b=0.143;// atomic radius of Aluminium
10 a1=(4*b)/(sqrt(2))  //Face centered cubic
11 mprintf("\n a1 = %f nm",a1)
12 r2=sqrt(3)*a1; //body diagonal length
```

```
13 mprintf("\n r2 = %f nm",r2)
14 r3=1/(r2); //linear density      //Taking inverse of
      r2 i.e body diagonal length
15 mprintf("\n r3 = %f atoms/nm",r3)
```

Scilab code Exa 3.15 Calculate the planar density of atoms in the 111 plane of bcc

```
1 //Example 3.15 (a)//
2 rW=0.137;//nm //atomic radius of tungsten (From
      appendix 2)
3 a=(4*rW)/(sqrt(3))//Body centered cubic
4 mprintf("a = %f nm",a)
5 l=sqrt(2)*a; // face diagonal length
6 mprintf("\n l = %f nm",l)
7
8 //The area of the  (111) plane within yhe unit cell
9 c=sqrt(3);//given
10 d=2;//given
11 h=(c/d)*l
12 //mprintf("h = %f ",h)
13 A=(1/2)*l*h
14 mprintf("\nA = %f nm^2",A)
15 c1=3;//atoms
16 d1=1/6;//atoms
17 ad=(c1*d1)/A
18 mprintf("\nad = %f atoms/nm^2",ad)
19
20 //(b)
21 // Following the calculations of sample problem 3.14
      b we find that the length of the body diagonal is
22 b=0.143;// atomic radius of Aluminium
23 a1=(4*b)/(sqrt(2))  //Face centered cubic
24 //mprintf("\n a1 = %f nm",a1)
25 l1=sqrt(2)*a1;
26 mprintf("\nl1 = %f nm",l1)
```

```
27 //the area of the (111) plane within the unit cell
      is
28 A1=(1/2)*l1*(c/d)*l1
29 mprintf("\nA1 = %f nm^2",A1)
30 e1=(1/2);//atoms
31 ad2=((c1*d1)+(c1*e1))/A1
32 mprintf("\nad2 %f atoms/nm^2",ad2)
```

Scilab code Exa 3.16 Calculate linear density of irons in the 111 direction of MgO

```
1 //Example 3.16//
2 // Following the calculations of sample problem 3.3
     we find that the length of the body diagonal is
3 rMg=0.078;//nm // Ionic radius of Magnesium (From
     Appendix 2)
4 rO=0.132;//nm // Ionic radius of Oxygen (From
     Appendix 2)
5 a=2*rMg+2*rO
6 //mprintf("a = %f nm",a)
7 l=sqrt(3)*a
8 mprintf("l = %f nm",l)
9 c=1;// Mg^2+
10 i=c/l//nm
11 mprintf("\n i = %f Mg^2+/nm",i)
12 //similarly
13 i2=c/l
14 mprintf("\n i2 = %f O2-/nm",i2)
15 mprintf("\n(1.37Mg2+ + 1.37O2-)/nm")
```

Scilab code Exa 3.17 Calculate the planar density of irons in the 111 plane of MgO

```
1 //Example 3.17//
2
```

```
// Following the calculations of sample problem 3.3
   we find that the length of the body diagonal is
rMg=0.078;//nm // Ionic radius of Magnesium (From
   Appendix 2)
rO=0.132;//nm // Ionic radius of Oxygen (From
   Appendix 2)
a=2*rMg+2*rO
//mprintf("a = %f nm",a)
l=sqrt(2)*a
mprintf("l = %f nm",l)
d=(sqrt(3)*l)/2 //height
//mprintf("\nd = %f",d)
A=(1/2)*l*d //planar area
mprintf("\n A = %f nm^-2",A)
c=2;//ions
id=c/A; //ionic density for Mg2+
mprintf("\n id = %f nm^-2  (ionic density for Mg2+)"
   ,id)
id1=c/A;//ionic density for O2-
mprintf("\n id1 = %f nm^-2  (ionic density for O2-)"
   ,id1)
mprintf("\n 13.1(Mg^2+ or O^2-)/nm^2")
```

Scilab code Exa 3.18 Calculate linear density of atoms along the 111 direction in

```
//Example 3.18//
rsi=0.117;//nm //atomic radius of silicon (From
   appendix 2)
a=8;//given // (a is obtain by cross multiplication)
l= a*rsi//nm //body diagonal length
mprintf("l = %f nm",l)
//the linear density
b=2;//atoms //From the figure 3.23 there are two
   atoms per lattice point therefore we choose value
    2 atoms in linear density
```

```
8 ld=b/l
9 mprintf("\n ld = %f atoms/nm",ld)
```

Scilab code Exa 3.19 Calculate planar density of atoms in the 111 plane of silicon

```
1 //Example 3.19//
2
3 e=0.117;//nm //atomic radius of silicon (From
     Appendix 2)
4 a=(8/sqrt(3))*e
5 mprintf("a= %f nm",a)
6 s=sqrt(2)*a
7 mprintf("\n s= %f nm",s)
8 i=2;//atoms //From the figure 3.23 there are two
     atoms per lattice point therefore we choose value
      2 atoms in planar density
9 A=(1/2)*s*(sqrt(3)/2)*s //area of traingle
10 mprintf("\n A = %f nm^2",A)
11 p=i/A;//planar density
12 mprintf("\n p = %f atoms/nm^2",p)
```

Scilab code Exa 3.20 Calculate the X ray wavelength that would produce first secon

```
1 //Example 3.20//
2 c=1;//centimeter // opposite side of a triangle
3 e=3;//centimeter // adjacent side of a triangle
4 a=atand(c/e)// (As tan = oppposite side/adjacent
     side)
5 mprintf("a = %f degree ",a)
6 a1=180;//degree
7 b1=2;//given
8 theta= (a1-a)/b1
9 mprintf("\ntheta = %f degree",theta)
```

```
10 //Braggs law
11 rMg=0.078;//nm // Ionic radius of Magnesium (From
      Appendix 2)
12 rO=0.132;//nm // Ionic radius of Oxygen (From
      Appendix 2)
13 a2=2*rMg+2*rO
14 //mprintf("a2 = %f nm",a2)
15 h=1; //spacing between adjacent plane
16 k=1;//spacing between adjacent plane
17 l=1;//spacing between adjacent plane
18 d=(a2)/sqrt(h^2+k^2+l^2)
19 mprintf("\n d = %f nm",d)
20 //substituting to obtain lamda for n=1
21 //for n=1
22 l1=b1*d*sind(theta)
23 mprintf("\n l1= %f nm",l1)
24 //for n=2
25 l2=(b1*d*sind(theta))/b1
26 mprintf("\n l2 = %f nm",l2)
27 //for n=3
28 l3=(b1*d*sind(theta))/e;
29 mprintf("\n l3 = %f nm",l3)
```

Scilab code Exa 3.21 Calculate the diffraction angle for the first 3 peaks in the

```
1 //Example 3.21//
2 a= 0.404;//nm //lattice parameter
3 a1=1;//given
4 b1=1;//given
5 c1=1;//given
6 b=sqrt(a1+b1+c1)
7 d111=a/b
8 mprintf("d111 = %f = nm",d111)
9 a2=2;//given
10 b2=0;//given
```

```
c2=0;//given
d200=a/sqrt(a2^2+b2+c2);
mprintf("\n d200 = %f nm",d200)
a3=2;//given
b3=2;//given
c3=0;//given
d220=a/sqrt(a3^2+b3^2+c3);
mprintf("\n d220 = %f nm",d220)
l=0.1542;//nm// from the figure 3.39
thetha111=asind(l/(a2*d111))
mprintf("\nthetha111 = %f degree",thetha111)
t111=a2*thetha111
mprintf("\nt111 = %f degree",t111)
thetha200=asind(l/(a2*d200))
mprintf("\nthetha200 = %f degree",thetha200)
t200=a2*thetha200
mprintf("\nt200 = %f degree",t200)
thetha220=asind(l/(a2*d220))
mprintf("\nthetha220 = %f degree",thetha220)
t220=a2*thetha220
mprintf("\nt220 = %f degree",t220)
```

Chapter 4

Crystal Defects and Non Crystalline Structure Imperfection

Scilab code Exa 4.1 Do Cu and Ni satisfy Hume Rotherys first rule for complete sol

```
1 //Example4.1//
2 rCu=0.128;//nm //atomic radius of copper
3 rNi=0.125;//nm //atomic radius of nickel
4 d=((rCu-rNi)/rCu)*100
5 mprintf("d = %f percent (<15percent)",d)
```

Scilab code Exa 4.2 How much oversize is the C atom in alpha Fe

```
1 //Example4.2//
2 a=4;//body-centered cubic as given in table 3.3
3 b=sqrt(3); //body-centered cubic as given in table
    3.3
4 c=1;// as we take R common from the equation
5 ri=(1/2)*(a/b)-c
```

```
6 mprintf("ri = %f R",ri)
7 //from the appendix 2, R=0.124nm giving
8 R=0.124;//nm //atomic radius of iron
9 ri1=ri*R
10 mprintf("\nri1 = %f nm",ri1)
11 rC=0.077;//nm //atomic radius of carbon from the
     appendix 2
12 R1=rC/ri1
13 mprintf("\nR1 = %f ",R1)
```

Scilab code Exa 4.3 Calculate the density of these sites

```
1 //Example4.3 //
2 a=2.70*10^6;//g/m^3 //density of aluminium
3 b=26.98;//g // atomic mass
4 c=0.602*10^24;//atoms //atomic mass unit
5 at=a/(b/c)
6 mprintf("at = %e atoms m^-3",at)
7 //Then density of vacant sites will be
8 d=2.29*10^-5;//atom^-1 //fraction of aluminium sites
      vacant at 400 degree celsius
9 v=d*at
10 mprintf("\nv= %e m^-3",v)
```

Scilab code Exa 4.4 Calculate the magnitude of the Burgers vector for alpha Fe Al

```
1 //Example4.4//
2 //(a)
3 RFe=0.124;//nm //atomic radius of iron
4 r=2*RFe
5 mprintf("r = %f nm",r)
6 //(b)
7 RAl=0.143;//nm //atomic radius of Aluminium
```

```
r1=2*RAl
mprintf("\nr1 = %f nm",r1)
//(c)
a=2;//given
RO=0.132;//nm // Ionic radius of Oxygen
b=cosd(30);//given
r2=2*(a*RO)*(b)
mprintf("\nr2 = %f nm",r2)
```

Scilab code Exa 4.5 Calculate the separation distance of dislocations in a low ang

```
//Example 4.5//

b=0.286;//nm // repeat distance between the adjacent
    atoms
t=2;// degree //Given
a=1;// rad
c=57.3;//degree
D=b/(t*(a/c))
mprintf("D = %f nm",D)
```

Scilab code Exa 4.6 Find the grain size number G for the microstructure

```
//Example 4.6//
a=3.98;//in.^2 // area of region
b=100;//grain density
c=300;//grain density
A100=a*(b/c)^2
mprintf("A100 = %f in^2",A100)
//Then the grain density becomes
d=32;//grains
N=d/A100
mprintf("\nN = %f grains/in^2",N)
```

```
11 i=2;//from the equation
12 e=log(N);
13 f=log(i);
14 j=1;//from the equation
15 G=(e/f)+j
16 mprintf("\nG = %f \nor \n G=7+",G)
```

Scilab code Exa 4.7 Calculate the APF of an amorphous thin film of nickel

```
1 //Example 4.7//
2
3 a=0.74;//APF for the fcc metal structure
4 b=8.84;//g/cm^3 //density of thin film of nickel
5 c=8.91;//g/cm^3;// density of normal nickel
6 APF=a*(b/c)
7 disp(APF)
```

Scilab code Exa 4.8 What is the diffraction angle for 100 keV electrons being diff

```
1 //Example 4.8//
2 a=0.404;//nm //lattice parameter
3 b=1;// lowest-angle
4 d111=a/sqrt(b^2+b^2+b^2)
5 mprintf("d111 = %f nm",d111)
6 l=3.7*10^-3;//nm //nanometer
7 c=2;//given
8 thetha=asind(l/(c*d111))
9 mprintf("\nthetha = %f degree",thetha)
10 t=2*thetha
11 mprintf("\nt = %f degree",t)
```

Chapter 5

Diffusion

Scilab code Exa 5.1 Calculate the activation energy Q for this oxidation process

```
1 //Example 5.1//
2 k=2.95*10^-4;// kg/(m^-4.s) //At 400 degree Celsius
     k rises
3 k1=1.05*10^-8;//kg/(m^-4.s) // The value of k at 300
     degree celsius
4 R=8.314;//J/(mol.K) //universal gas constant
5 T=673;//K //Kelvin //absolute temperature
6 T1=573;//K //Kelvin //absolute temperature
7 a=log(k/k1);// Taking antilog to remove exponential
     term
8 //mprintf("a=%e ",a)
9 c=(1/T)-(1/T1); //subtracting the term
10 //mprintf("c = %e ",c)
11 Q=(-(a/c))*R //cross multiplication of the term
12 mprintf("Q = %e J/mol = 328 kJ/mol",Q)
```

Scilab code Exa 5.2 Calculate the fraction at 660 degree C just below its melting

```
1 //Example 5.2//
2 nv=2.29*10^-5;//the fraction of aluminium lattice
     sites vacant
3 Ev=0.76;//eV //elevtrom volts
4 k=86.2*10^-6;//eV //Boltzmann's constant
5 T=673;//K //Kelvin //absolute temperature
6 T1=933;// K //Kelvin //absolute temperature
7 //At 400degree C(=673K)
8 a=Ev/(k*T)// solving the exponential raise to
     equation
9 //mprintf("a = %f ",a)
10 C=nv*%e^a
11 mprintf("C = %f",C)
12 //At 660 degree C (=993K)
13 b=Ev/(k*T1)//solving the exponential raise to
     equation
14 //mprintf("b = %f ",b)
15 N=C*%e^-b
16 mprintf("\nN = %e ",N)
17 mprintf("\nor roughly nine vacancies occur for every
     10,000 lattice sites ")
```

Scilab code Exa 5.3 Estimate the flux of carbon atoms into the steel in this near

```
1 //Example 5.3//
2 c1=5;//at % //drop in carbon concentration 5 to 4 at
     %
3 c2=4;// at % //drop in carbon concentration 5 to 4
     at %
4 x1=1;//mm //millimetre
5 x2=2;//mm //millimetre
6 d=(c1-c2)/(x1-x2)
7 mprintf("d = %i at percent /mm",d)
8 a=7.63;//g/cm^3 //gram per cubic centimeter
9 b=0.6023*10^24;//atoms //Avgardo's number
```

```
10 c=55.85;//g //atomic mass of iron (from appendix 1)
11 p=a*(b/c)
12 mprintf("\np = %e atoms/cm^3",p)
13 a1=0.01;//given
14 c1=1;//mm //millimetre
15 d1=10^6;//cm^3/m^3
16 e1=10^3;//mm/m
17 d2=-((a1*p)*c1)*(d1)*(e1)
18 mprintf("\nd2 = %e atoms/m^4",d2)
19 D0=20*10^-6;//m^2/s //preexponential constant
20 Q=142000;//J/mol //activation energy for defect
      motion
21 R=8.314;//J/mol/K //universal gas constant
22 T=1273;//K //Kelvin // absolute temperature
23 Dc=D0*(%e^-(Q/(R*T)))
24 mprintf("\nDc = %e m^2/s",Dc)
25 c2=(-8.23*10^29);//atoms/m^4
26 J=-Dc*c2
27 mprintf("\nJ =%e atoms/(m^2.s)",J )
```

Scilab code Exa 5.4 Calculate how long it would take at 1000 degree C to reach a c

```
1 //Example 5.4//
2 cx=0.5;//carbon content
3 b=1;//given
4 e=b-cx
5 mprintf("e = %f ",e)
6 c=0.4755;//As z= 0.45 therefore erf (z) is obtained
     //Interpolating table 5.1 gives
7 d=0.5205;//As z=0.50 therefore erf(z) is obtained //
     Interpolating table 5.1 gives
8 g=0.45;//given
9 z=(((e-c)/(d-c))*(e-g))+g
10 mprintf("\nz = %f",z)
11 x=1*10^-3;//Using the diffusivity from sample
```

```
    problem 5.3
D=2.98*10^-11;//m^2/s //Arrhenius equation
m=(x^2)/(4*(z^2)*D)
//mprintf("\nm = %e ",m)
i=1;//h //hour
j=3.6*10^3;//s //second
t=m*(i/j)
mprintf("\nt = %f h",t)
```

Scilab code Exa 5.5 Recalculate the carburization time for the conditions using th

```
//Example 5.5//
x=1*10^-3;//m// Using the diffusivity from sample
    problem 5.3
D=2.98*10^-11;//m^2/s //arrhenius equations
a=0.95;//from the figure 5.11
d=(x^2)/((a^2)*(D))// calculating the value of d
mprintf("d = %e h",d)
b=1;//h //hour
c=3.6*10^3;//s //second
t=d*(b/c)
mprintf("\nt = %f h",t)
```

Scilab code Exa 5.6 What is the carburization temperature

```
//Example 5.6//
x=0.75*10^-3;//m //meter //given
t=3.6*10^4;//s //seconds //time
a=0.95;//given
D=(x^2)/((a^2)*(t))
mprintf("D = %e m^2/s",D)
b=20*10^-6;//m^2/s //preexponential constant
```

```
c=142000;//J/mol //activation energy for defect
    motion
d=8.314;//J/(mol.K)//universal gas constant
e=c/d
//mprintf("\ne = %e",e)
y=(-log(D/b))
T1=inv(y/e)
mprintf("\nT1 = %i K  = 952 degree C",T1)
```

Scilab code Exa 5.7 Calculate the mass of hydrogen being purified per hour

```
//Example 5.7//
D=(-1.0*10^-8);//m^2/s //constant diffusion
    coefficient
ch=1.5;//kg/m^3 //constant surface concentrationsof
    the diffusing species
ct=0.3;//kg/m^3 //constant surface concentrationsof
    the diffusing species
x=5*10^-3;//m //meter //solid of thickness
y=(-D)*(((ch-ct)/(x)))
//mprintf("y = %e kg/m^2 h",y)
t=3.6*10^3;//s/h //time
J=y*t
mprintf("J = %e kg/m^2.h",J)
//The total mass of hydrogen being purified will
    then be this flux times the membrane area
A=0.2;//m^2 //membrane area
m=J*A
mprintf("\nm = %e kg/h",m)
```

Scilab code Exa 5.8 Calculate the penetration of B into A along the grain boundary

```
//Example 5.8//
```

```
2
3  cx=0.01;// distance of x
4  c0=0;////for initially pure A
5  c=cx-c0
6  mprintf("c = %f ",c)
7  a=1;//given
8  e=a-c
9  mprintf("\ne = %f ",e)
10 b=0.9928;//As z= 1.90 erf(z)=0.9928 //Interpolating
       table 5.1 gives
11 d=0.99;//Interpolating table 5.1 gives
12 f=0.9891;//As z=1.80 erf(z)=0.9891 //Interpolating
       table 5.1 gives
13 h=1.90;//given
14 i=1.80;//given
15 z=-((((b-d)/(b-f))*(h-i))-h)
16 mprintf("\nz = %f ",z)
17 D=1*10^-10;//m^2/s// grain boundary
18 D1=1*10^-14;//m^2/s // volume of bulk grain
19 t=1;//h //hour //time
20 t1=3.6*10^3;//s/h //time
21 x=2*z*sqrt(D*t*t1)
22 mprintf("\nx = %e m ",x)
23 a1=10^3;//(As 1milli = 10^-3)
24 a2=a1*x
25 mprintf(" = %f mm",a2)
26 //(b) For comparison
27 x1=2*z*sqrt(D1*t*t1)
28 mprintf("\nx1 = %e m ",x1)
29 b1=10^6;//(As mew = 10^-6)
30 b2=b1*x1
31 mprintf(" = %f mew m",b2)
```

Chapter 6

Mechanical Behaviour

Scilab code Exa 6.1 Calculate E Y S T S and percent elongation at failure for the

```
1 //Example 6.1//
2
3 s=300*10^6;//Pa //pascal //strain
4 a=0.0043;// From the figure
5 E1=s/a
6 mprintf("E1 = %e GPa= 70GPa ",E1)
7 mprintf("  (As G= 10^9)")
8 //The 0.2% offset construction gives
9 mprintf("\nY.S. =410MPa")
10 //The maximum for the stress stain curve gives
11 mprintf("\n T.S = 480MPa")
12 ef=0.08;//percent //the strain at fracture
13 f=100*ef
14 mprintf("\n f = %i percent",f)
```

Scilab code Exa 6.2 Calculate the elastic recovery that would occur upon removal o

```
1 //Example 6.2//
```

```
2 p=50000;//N //tensile load
3 A0=5*10^-3;//m //area of the sample parallel to the
     applied load
4 s=p/(%pi*A0^2)
5 mprintf("s = %e N/m^2  637 MPa",s)
6 mprintf("  (As M= 10^6)")
7 s1=637*10^6;//Pa //Pascal //modulus of elasticity
8 E=200*10^9;//Pa // Pascal //Youngs Modulus
9 E1=s1/E
10 mprintf("\n E1 = %e ",E1)
```

Scilab code Exa 6.3 Calculate the diameter if this rod is subjected to a 6 kN comp

```
1 //Example 6.3//
2
3 P=6*10^3//N //Newton // load on the sample
4 A0=(10/2)*10^-3;//N/m^2
5 s=P/(%pi*A0^2)
6 mprintf("s = %e N/m^2 = 76.4 MPa",s)
7 mprintf("  (As M= 10^6)")
8 s1=76.4;//MPa //Megapascal //modulus od elasticity
9 E=70*10^3;//MPa//Megapascal //Young's Modulus
10 e=s1/E
11 mprintf("\n e = %e",e)
12 //the strain of diameter is calculated as
13 v=0.33;//given
14 ed=-v*e
15 mprintf("\n ed = %e ",ed)
16 //resulting diameter
17 d0=10;//mm
18 df=d0*(ed+1)
19 mprintf("\n df = %f mm",df)
20 //compressive stress
21 ed1=+3.60*10^-4;//the diameter strain will be of
     equal magnitude but opposite sign
```

```
22 df1=d0*(ed1+1);
23 mprintf("\n df1 = %f mm",df1)
```

Scilab code Exa 6.4 Calculate the breaking strenght of the plate

```
1 //Example 6.4//
2
3 r0=0.132;//nm //Ionic radius of Oxygen (From
     appendix 2)
4 p=2*r0
5 mprintf("p = %f nm",p)
6 a=7.0*10^9;//Pa //The theoretical strength of the
     defect free glass
7 p1=0.264*10^-9//m
8 c=1*10^-6;//m //crack length
9 s=(1/2)*a*(p1/c)^(1/2)
10 mprintf("\ns = %e Mpa  = 57MPa (As M =10^6)",s)
```

Scilab code Exa 6.5 Calculate the flexural modulus for this engineering polymer

```
1 //Example 6.5//
2 L=50*10^-3;//m //Distance between support
3 m=404*10^3;//N/m //Initial slope of load-deflection
     curve
4 b=13*10^-3;//m //test piece geometry
5 h=7*10^-3;//m //test piece geometry
6 E=((L^3)*m)/(4*b*h^3)
7 mprintf("E = %e N/m^2  =2830MPa  (As M= 10^6)",E)
```

Scilab code Exa 6.6 What is the resulting strain

```
1 //Example 6.6//
2
3 E=830;//MPa //Megapascal //Young's Modulus
4 s=1;//MPa //MegaPascal //modulus of elasticity
5 e=s/E
6 mprintf("e = %e",e)
7 //(b)
8 E1=1.3;//MPa//Megapascal //Young's Modulus
9 e1=s/E1
10 mprintf("\n e1 = %f",e1)
11 //(c)E=200 GPa= 2*10^5 Mpa
12 E2=2*10^5;//MPa//Megapascal //Young's Modulus
13 e2=s/E2//Mpa
14 mprintf("\n e2 = %e",e2)
```

Scilab code Exa 6.7 Calculate the modulus of elasticity along the 111 directions

```
1 //Example 6.7//
2
3 //From hooke law'
4 s=0.2489;//nm //nanometer // modulus of elasticity
5 s1=0.2480;// nm //nanometer // modulus of elasticity
6 e=(s-s1)/s1
7 printf("e = %f ",e)
8 s2=1000;//Mpa //MegaPascal //sigma
9 E=s2/e
10 mprintf("\n E = %e",E)
11 mprintf("  275   GPa  (As G=10^9) (Answer calculated
    in the textbook is wrong)")
```

Scilab code Exa 6.8 What tensile stress is necessary to reach the critical resolve

```
1 //Example 6.8//
```

```
si=0.690;//MPa //Megapascal //tensile stress
a=cosd(40);//degree
b=cosd(60);//degree
torque=si*a*b
mprintf("torque = %f MPa (38.3 psi)",torque)
t=0.94;//MPa //MegaPascal //torque
sig=t/(a*b)
mprintf("\n sig = %f Mpa (356 psi)",sig)
```

Scilab code Exa 6.9 Calculate the BHN of this alloy

```
//Example6.9//
P=3000;//kg //load
D=10;//mm//diamter sphere of tungsten carbide
d=3.91;//mm //diameter impression in the iron
   surface
BHN=(2*P)/((%pi*D)*(D-sqrt(D^2-d^2)))
mprintf("BHN = %i",BHN)
//From the Figure 6.28b
printf("\n(TS)BHN=240 = 800 Mpa")
```

Scilab code Exa 6.10 Predict the creep rate at a service temperature of 600 degree

```
//Example 6.10//

ap=5*10^-1;//percent per hour
Q=2*10^5;//J/mol //activation energy
R=8.314;//J/mol.K// universal gas constant
T=1273;//K //Kelvin //absolute temperature
T1=873;//given //absolute temperature
C=ap*%e^((Q)/(R*T))
mprintf("C = %e percent per hour",C)
```

```
10 //applying this amount to the service temprature
     yield
11 C1=C*%e^-((Q)/(R*T1))
12 mprintf("\n C1 = %e percent per hour",C1)
```

Scilab code Exa 6.11 What is the service temperature

```
1 //Example 6.11//
2 s=125;//ksi
3 s=95;//ksi
4 s=65;//ksi
5 T=540;//degree C
6 T=595;//degree C
7 T=650;//degree C
8 x=[540 595 650]
9 y=[125 95 65 ]
10 plot2d(x,y, style=1)
11 ylabel("stress (ksi)","fontsize",2 );
12 xlabel("T(degree C)")
13 mprintf(" T = 585 degree C")
```

Scilab code Exa 6.12 If the activation energy for the relaxation process is 30 kJ

```
1 //Example 6.12//
2
3 s1=2;//MPa //MegaPascal
4 s2=1;//MPa //Megapascal
5 a=60;//days //relaxation time for a rubber band at
     25 degree C
6 t=(a)*log(s1/s2)
7 mprintf("t = %f days",t)
8 Q=30*10^3;//J/mol //activation energy for the
     relaxation process
```

```
R=8.314;//J/(mol.K) // universal gas constant
T1=308;//K //Kelvin //absolute temperature
T2=298;//K //Kelvin //absolute temperature
t35=a*exp((Q/R)*((1/T1)-(1/T2)))
mprintf("\n t35 = %f days",t35)
```

Scilab code Exa 6.13 Calculate the working range and the melting range for this gl

```
//Example 6.13//
a=514;//K //Kelvin //Temperature
b=273;//K //Kelvin //Temperature
apt=a+b
mprintf("apt = %i K for eta = 10^13.4P",apt)
c=696;//K //Kelvin //Temperature
spt=c+b//for eta=10^7.6P
mprintf("\n spt = %i K",spt)
i=(10^13.4); //P //Pascal //preexponential constant
j=(10^7.6);//P // Pascal //preexponential constant
f=8.314;//J/(mol K) //universal gas constant
a1=log(i/j); //(Taking antilog of i and j to remove
   exponential term)
//mprintf("\na1 = %f ",a1)
b1=(1/apt)-(1/spt);//(subtracting the temperature)
//mprintf("\nb1 = %e ",b1)
Q=(a1/b1)*f
mprintf("\nQ = %e J/mol  = 465kJ (As 1K = 10^3)",Q)
eta0=i*%e^-((Q)/(f*apt))
mprintf("\n eta0 = %e P",eta0)
h=10^4;//given
//for eta=10^4 P and eta=10^8 P
//for eta = 10^4
T=Q/((f)*log(h/eta0))
mprintf("\n T = %i K = 858 degree C",T)
//for eta=10^8P
h1=10^8;//P //Pascal
```

```
27 T1=Q/((f)*log(h1/eta0))
28 mprintf("\n T1 = %i K = 680 degree C",T1)
29 //Therefore working range = 680 to 858 degree C
30
31 //For melting range eta=50 to 500 P
32  eta=50;//P //Pascal
33 T2=Q/((f)*log(eta/eta0))
34 mprintf("\n T2 = %i K = 993 degree C",T2)
35  eta1 = 500;// P //Pascal
36 T3=Q/((f)*log(eta1/eta0))
37 mprintf("\n T3 = %i K = 931 degree C",T3)
38 mprintf("\n melting range = 931 to 993 degree C")
```

Chapter 7

Thermal Behavior

Scilab code Exa 7.1 Show that the rule of thumb that the heat capacity of a solid

```
1 //Example 7.1//
2
3 R=8.314;//J/mol.K // Gas constant (From appendix 3)
4 a=3*R
5 mprintf("a = %f J/mol K",a)
6 //for aluminum there are 26.98 g per g-atom
7 b=1;//mol //
8 c=26.98;//g //grams // atomic mass of aluminium (
     From appendix 1)
9 d=1000;//g/kg
10 a1=a*(b/c)*d
11 mprintf("\n a1 = %i J/kg.K",a1)
```

Scilab code Exa 7.2 Calculate the increase in lenght produced by this heating

```
1 //Example 7.2//
2 a=8.8*10^-6;//mm/(mm degree C) //linear coefficient
     of thermal expansion
```

```
3 L0=0.1;//mm //Given direction
4 T=1000;//degree Celsius // Temperature
5 T1=25;//degree Celsius //Temperature
6 dL=a*L0*(T-T1)
7 mprintf("dL = %e m  ",dL)
8 b=10^3;// (As 1 milli = 10^-3 milli)
9 dL1= dL*b
10 mprintf("\ndL1 = %f mm (As 1 milli = 10^-3 milli)",
   dL1)
```

Scilab code Exa 7.3 Calculate the steady state heat transfer rate through a sheet

```
1 //Example 7.3//
2 k=398;//J/s.m.K // thermal conductivity
3 T=0;//degree Celsius //temperature gradient
4 T1=50;//degree Celsius //temperature gradient
5 x=10*10^-3;//m //metre
6 A=-k*((T-T1)/x)
7 mprintf("A = %e J/m^2.s",A)
```

Scilab code Exa 7.4 Calculate the stress that would be generated in the tube if it

```
1 //Example 7.4//
2
3 //The thermal expansion coefficient for AL2O3 over
   the range
4 a=8.8*10^-6//mm/(mm degree C) //Linear coefficient
   of Thermal expansion
5 //If we take room temperature as 25degree C
6 T=1000;//degree C //Temperature
7 T1=25;//degree C //Temperature
8 e=a*(T-T1)
9 mprintf("e = %e",e)
```

```
10 //an E for sintered Al2O3 as
11 E=370*10^3;//MPa // sintered Al2O3
12 si=E*e
13 mprintf("\n si = %i MPa (compressive) (Answer
      calculated in textbook is wrong)",si)
```

Chapter 8

Failure Analysis and Preventation

Scilab code Exa 8.2 Calculate the size of a surface crack that will lead to catast

```
1 //Example 8.2//
2
3 Y=1;// dimensionless geometry factor
4 YS=1460//MPa //MegaPascal // overall stress applied
     at failure
5 b=0.5;//Y.S //given
6 Kic=98;//MPa sqrt(m) //fracture toughness
7 a=(Kic^2)/((%pi)*(b*YS)^2)
8 mprintf("a = %e m    = 5.74 mm    (As 1 milli = 10^-3 )
     ",a)
```

Scilab code Exa 8.3 Calculate the maximum service stress available with SiC and pa

```
1 //Example 8.3//
2
3 a=25*10^-6;// m // length of surface crack
```

```
4 // (a) For Sic,
5 b=3;//MPa sqrt(m) //fracture toughness
6 s1=b/(sqrt(%pi*a))
7 mprintf("s1 = %i MPa",s1)
8 // (b) For PSZ,
9 c=9;//MPa sqrt(m)// fracture toughness
10 s2=c/(sqrt(%pi*a))
11 mprintf("\n s2 = %i MPa   (Answer calculated in
     textbook is wrong)",s2)
```

Scilab code Exa 8.4 Estimate a maximum permissible service stress knowing that loa

```
1 //Example 8.4//
2 T.S=800;//MPa
3 F.S=T.S/4
4 mprintf("F.S = %i MPa",F.S)
5 ss=F.S/2
6 mprintf("\n ss = %i Mpa",ss)
```

Scilab code Exa 8.5 What is the time to fracture at minus 50 degree C at the same

```
1 //Example8.5//
2 Q=78.6*10^3;//J/mol //Activation energy
3 R=8.314;//J/mol //universal gas constant
4 T=323;//K //Kelvin //absolute temperature
5 T1=223;//K //Kelvin //absolute temperature
6 C=1/(%e^-((Q)/(R*T)))
7 mprintf("C = %e s^-1",C)
8 t50=C*(%e^-(Q/(R*T1)))
9 mprintf("\n t50 = %e s^-1",t50)
10 t=5.0*10^5;//s //seconds
11 a=1;//h //hour
12 b=3.6*10^3;//s //seconds
```

```
13 t1=t*(a/b)
14 mprintf("\n t1 = %i h  =5days, 20h (Answer
      calculated in the textbook is wrong)",t1)
```

Scilab code Exa 8.6 Calculate the fraction of X ray beam intensity transmitted thr

```
1 //Example 8.6//
2
3 u=0.293;//mm^-1 //linear absorption coefficient for
      the material
4 x=10;//mm //x-ray beam intensity transmitted
5 I=%e^-(u*x)
6 disp(I)
```

Scilab code Exa 8.7 Calculate the fraction reflected for the interface but with th

```
1 //Example 8.7//
2 //(a)
3 a=2.70;//Mg/m^3 //Density of aluminium (From
      appendix 1)
4 b=6320;//m/s //velocity of sound
5 ZAl=a*b
6 mprintf("ZAl = %e Mg/(m^2s)",ZAl)
7 a1=7.85;//Mg/m^3 //Density of Manganese (From
      Appendix 1)
8 b1=5760;//m/s //Velocity of sound
9 Zst=a1*b1
10 mprintf("\n Zst = %e Mg/(m^2s)",Zst)
11 Ir=[(Zst-ZAl)/(Zst+ZAl)]^2
12 mprintf("\n Ir = %f ",Ir)
13
14 //(b) For the reverse direction of ultrasonic-pulse
      travel
```

```
15 Ir1=[(ZAl-Zst)/(ZAl+Zst)]^2
16 mprintf("\n Ir1 = %f ",Ir1)
```

Chapter 9

Phase Diagrams Equilibrium Microstructural Development

Scilab code Exa 9.1 Calculate the degrees of freedom for this alloy and comment on

```
1 //Example 9.1//
2 //Assuming constant pressure of 1 atm above the
     alloy
3 //There are two components (Pb &Sn) and two phases
4 c=2;
5 p=2;
6 F=c-p+1
7 disp(F)
```

Scilab code Exa 9.3 Calculate the amount of each phase

```
1 //Example 9.3//
2
3 xss=66;//wt % //solid solution composition
4 xL=18;//wt % //liquid solution composition
5 x=50;//x is overall composition
```

```
a=1;//kg //weight of alloy
mL=((xss-x)/(xss-xL))*a;
mprintf("mL = %f kg ",mL)
b=10^3;//grams ////As 1kg= 10^3grams
mL1=mL*b
mprintf("\nmL1= %i g",mL1)
mss=((x-xL)/(xss-xL))*a
mprintf("\nmss = %f kg ",mss)
mss1=mss*b //As 1kg= 10^3grams
mprintf("\nmss1=%i g",mss1)
```

Scilab code Exa 9.4 Calculate the amount of each phase alpha and Fe3C present

```
//Example 9.4//

xfe3c=6.69;//wt % //Fe3C composition
x=0.77;//wt % //x is the overall composition
xa=0;//wt % //composition of two phases
a=1;//kg
ma=((xfe3c-x)/(xfe3c-xa))*a
mprintf("ma = %f kg ",ma)
b=10^3;//g //As 1kg = 10^3grams
ma1=ma*b
mprintf("\nma1 = %i g ",ma1)
mfe3c=((x-xa)/(xfe3c-xa))*a
mprintf("\nmfe3c = %f kg ",mfe3c)
mfe3c1=mfe3c*b
mprintf("\nmfe3c1    = %i g",mfe3c1)
```

Scilab code Exa 9.5 Estimate the mole percent of each phase present at room temper

```
//Example 9.5//

```

```
xcub=15;//wt % //cubic phase
x1=8;//mol % CaO//x1 is the overall composition
xmono=2;//wt % //monoclinic phase
monoclinic=(xcub-x1)/(xcub-xmono)*100
mprintf("monoclinic = %f mol percent",monoclinic)
cubic=(x1-xmono)/(xcub-xmono)*100
mprintf("\ncubic = %f mol percent",cubic)
```

Scilab code Exa 9.6 Calculate what weight fraction of these beta phase at T3 is pr

```
    //Example 9.6//
//(a)
x1=70;//wt % //x1 is the overall composition
xa=30;//wt % //composition of two phases
xb=90;//wt % //composition of two phases
xl=60;//wt %//
a=1;//kg
mb1=((x1-xa)/(xb-xa))*a
mprintf("mb1 = %f kg ",mb1)
b=10^3;//g//As 1kg = 10^3grams
mb3=mb1*b////As 1kg = 10^3grams
mprintf("\nmb1= %i g",mb3)
mb2=((x1-xl)/(xb-xl))*a
mprintf("\n mb2 = %f kg ",mb2)
mb4=mb2*b//As 1kg = 10^3g
mprintf("\nmb4= %i g",mb4)
fp=mb4/mb3
mprintf("\n fp =%f ",fp)
```

Scilab code Exa 9.7 Calculate the amount of proeutectoid alpha at the grain bounda

```
//Example 9.7//

```

```
3 xy=0.77;//wt % // composition of two phases
4 x1=0.50;//wt % //x1 is the overall composition
5 xa=0.02;//wt % //composition of two phases
6 a=1;//kg
7 ma=((xy-x1)/(xy-xa))*a
8 mprintf("ma = %f kg ",ma)
9 b=10^3;//grams //As 1 kg = 10^3grams
10 ma1=ma*b
11 mprintf ("\nma1= %i g",ma1)
```

Scilab code Exa 9.8 Calculate the amount of graphite flakes present in the microst

```
1 //Example 9.8//
2 //(a) 1153degre c is just below he eutectic
     temperature
3 x1=3.00;//wt % //x1 is the overall composition
4 xc=2.08;//wt % //composition of two phases
5 xC=100;//wt %//composition of two phases
6 a=1;//kg
7 mc=((x1-xc)/(xC-xc))*a
8 mprintf("mc = %f kg ",mc)
9 b=10^3;//g //As 1kg = 10^3 grams
10 mc2=mc*b
11 mprintf("\nmc2= %f g",mc2)
12 //(b) At room temperature, we obtain
13 xa=0;
14 mc1=((x1-xa)/(xC-xa))*a
15 mprintf("\n mc1 = %f kg ",mc1)
16 mc3=mc1*b
17 mprintf("\nmc3= %i g",mc3)
```

Scilab code Exa 9.9 How is the silicon distributed in the microstructure at 576 de

```
1  //Example 9.9//
2  xl=12.6;//wt % //liquid solution composition
3  xa=1.6;//wt %// composition of two phases
4  x1=10;//wt % //x1 is the overall composition
5  xb=100;//wt %//composition of two phases
6  a=1;//kg
7  ma=((xl-x1)/(xl-xa))*a
8  mprintf("ma = %f  kg ",ma)
9  b=10^3;//g //As 1kg = 10^3grams
10 ma2=ma*b
11 mprintf("\nma2= %i g",ma2)
12
13 //At 576degree C, the overall microstructure is
      alpha+beta, the amount of each are
14 ma1=((xb-x1)/(xb-xa))*a
15 mprintf("\nma1 = %f kg ",ma1)
16 ma3=ma1*b
17 mprintf("\nma3= %i g",ma3)
18 mb=((x1-xa)/(xb-xa))*a
19 mprintf("\nmb = %f kg  ",mb)
20 mb1=mb*b
21 mprintf("\nmb1= %i g",mb1)
22 ae= ma3-ma2
23 mprintf("\nae = %i g",ae)
24 a1=0.016;//wieght fraction
25 a2=1.000;//wieght fraction
26 si1=(a1)*(ma2)
27 mprintf("\nsi1 = %f g",si1)
28 si2=(a1)*(ae)
29 mprintf("\nsi2 = %f g",si2)
30 si3=(a2)*(mb1)
31 mprintf("\nsi3 = %i g",si3)
```

Scilab code Exa 9.10 What is the maximum amount of thetha phase that will precipit

```
1 //Example 9.10//
2
3 x=4.5;//wt % //x is overall composition
4 xk=0;//wt %//composition of two phases
5 xth=53;//wt % //composition of two phases
6 wt=(x-xk)/(xth-xk)*100
7 mprintf("wt = %f percent ",wt)
```

Scilab code Exa 9.11 For a temperature of 200 degree C determine the phase present

```
1 //Example 9.11//
2 //(a)
3 xL=54;//wt % //liquid solution composition
4 x=50;//wt % //x is the overall composition
5 xa=18;//wt % //composition of two phases
6 wta=(xL-x)/(xL-xa)*100
7 mprintf("wta = %f percent",wta)
8 wtL=(x-xa)/(xL-xa)*100
9 mprintf("\nwtL =%f percent",wtL)
10 //Similarly, at 100 degree C, we obtain
11 xb=99;//wt % //composition of two phases
12 xa=5;//wt % //composition of two phases
13 wta1=(xb-x)/(xb-xa)*100
14 mprintf("\nwta1 = %f ",wta1)
15 wtb=(x-xa)/(xb-xa)*100
16 mprintf("\nwtb = %f percent",wtb)
```

Scilab code Exa 9.12 Determine the phase present their compositions and their amou

```
1 //Example 9.12//
2
3 Al2O3=1;// solid composition
4 SiO2=2; // solid composition
```

```
molp=(Al2O3/(Al2O3+SiO2))*100
mprintf("molp = %f  percent",molp)
xm=60;//mol % //composition of mullite
x=33.3;//mol% // x is overall comosition
xs=0;//mol % //composition of SiO2
mols=(xm-x)/(xm-xs)*100
mprintf("\nmols = %f  mol percent ",mols)
molm=(x-xs)/(xm-xs)*100
mprintf("\nmolm = %f mol  percent",molm)
```

Chapter 10

Kinetics Heat Treatment

Scilab code Exa 10.1 Calculate the activation energy for self diffusion in this al

```
1 //Example 10.1//
2
3 T1=1173;//K// Absolute Temperature
4 T2=673;//K // Absolute Temperature
5 R=8.314;//J/mol.K // Universal gas constant
6 a=10^6;//(G900/G400)
7 C=10^-3;//preexponential term
8 Q=-(R*log(a))/((1/T1)-(1/T2))*C
9 mprintf("Q = %i KJ per mol",Q)
```

Scilab code Exa 10.4 Estimate the quench rate needed to avoid pearlite formation

```
1 //Example 10.4//
2
3 //(a)= 0.5 wt % C we must quenchfrom the austenite
    boundary (770degree C) to ~520 degree in ~0.6,
    giving
4 a=770;//degree C //austenite boundary
```

```
5 b=520;//Degree C //temprature
6 t=0.6;//s //seconds // time
7 dt1=(a-b)/t
8 mprintf("dt1 = %i degree C/s",dt1)
9 //(b)=0.77 wt % C steel, we quench from the
    eutectoid temperature(727degree C) to ~550degree
    C in 0.7s, giving
10 a1=727;//degree C //eutectoid temperature
11 b1=550;//degree C //temperature
12 t1=0.7;//s//seconds //time
13 dt2=(a1-b1)/t1
14 mprintf("\ndt2 = %i degree C/s",dt2)
15 //(c)= 1.13 wt %C steel we quench from the austenite
    boundary (880degree C) to ~550degree C in ~3.5
16 a2=880;//degree C //eutectoid temperature
17 t3=0.35;//s //seconds //time
18 dt3=(a2-b1)/t3
19 mprintf("\ndt3 = %i degree C/s",dt3)
20 mprintf("\nThe calculated answer in the textbook is
    wrong")
```

Scilab code Exa 10.5 Calculate the time required for austempering at 5 degree C ab

```
1 //Example 10.5//
2 //(a) = For 0.5 wt % C steel indicates that complete
    bainite formation will have ocuurred 5degree C
    above Ms,by
3 a=180;//s //second
4 b=1;//m //minute
5 c=60;//s//seconds
6 d=a*(b/c)
7 mprintf("d= %i min",d)
8 //(b)= For 0.77 wt % C steel gives a time of
9 a1=1.9*10^4;//s //seconds
10 b1=3600;//s/h //seconds per hour
```

```
11 c1=a1/b1
12 mprintf("\nc1 = %f h ",c1)
13 //(c)= for 1.13 wt % C steel gives an austempering
      time of
14 mprintf("\n= Figure 10.15 for 1.13 wt percent C
      steel gives an austempering time of ~1day ")
```

Scilab code Exa 10.6 What cooling rate was experienced by the forging at the point

```
1 //Example 10.6//
2
3 //Jominy end squench test on this alloy produces a
      hardness of Rockwell C45 at 22/16 in from the
      quenched end which is equal
4 a=22;//in
5 b=16;//in
6 c=25.4;//mm/in
7 Dqe=(a/b)*c
8 mprintf("Dqe = %i mm",Dqe)
9
10 x=[0 2 4 6 8 10 15 20 25 30 40 50];
11 y=[600 300 150 70 50 20 15 10 6 5 3 2];
12 plot2d(x,y, style=1);
13 xlabel("Distance from quenched end ,Dqe (Jominy
      distance)", "fontsize", 3)
14 ylabel("Cooling rate at 700 degree C C/sec ", "
      fontsize", 3)
15 mprintf("\nFrom the figure which applies  to carbon
      and low-alloy steels ,we see that the cooling rate
       was approximately \n 4 degree C/s (at 700 degree
       C) ")
```

Scilab code Exa 10.8 What is the maximum amount of Guinier Preston zones to be exp

```
1 //Example 10.8//
2 x=4.5;//wt % // x is the overall composition
3 xk=0;//wt % // composition for two phases
4 xth=53;//wt % //coposition for two phases
5 //(a)
6 wt=(x-xk)/(xth-xk)*100
7 mprintf("wt = %f percent",wt)
8 mprintf("\n As the G.P zones are precursors to the
    equlibrium precipitation the maximum amount would
     be 8.49 percent")
```

Scilab code Exa 10.9 How this alloy should compare with the trend

```
1 //Example 10.9//
2
3 T1=290;//degree C //recrystallization temperature
4 T2=920;// degree C //solidus temperature
5 T3=273;//K //Kelvin
6 T4=(T1+T3)/(T2+T3)
7 disp(T4)
```

Scilab code Exa 10.10 Calculate the maximum amount of monoclinic phase you would e

```
1 //Example 10.10//
2 xc=15;
3 x=7;
4 xm=2;
5 m=round((xc-x)/(xc-xm)*100)
6 mprintf("m = %i mol percent",m)
```

Scilab code Exa 17.10 Calculate the photon wavelenght necessary to promote a donor

```
1 //Example 10.10//
2 xc=15;//mol % //cubic phase composition of CaO
3 x=7;//mol % //x for overall composition
4 xm=2;//mol % //monoclinic phase composition of CaO
5 m=(xc-x)/(xc-xm)*100
6 mprintf("m = %i mol percent",m)
```

Chapter 11

Metals

Scilab code Exa 11.1 for every 100000 atoms of an 8630 low alloy steel how many at

```
1  //Example11.1//
2  Ni=0.55;//wt % // steel and nominal alloy content
3  Cr=0.50;//wt % //steel and nominal alloy content
4  Mo=0.20;//wt % //steel and nominal alloy content
5  C=0.30;//wt %//steel and nominal alloy content
6  a=100-(Ni+Cr+Mo+C)
7  mprintf("a = %f g Fe ",a)
8  a1=55.85;//g /mol // atomic mass of iron
9  b=0.6023*10^24;//atoms/ mol //Avagardo's constant
10 NFe=(a/a1)*b
11 mprintf("\nNFe = %e atoms",NFe)
12 //similarly
13 c=58.71;//g/mol // atomic mass of nickel
14 Nni=(Ni/c)*b
15 mprintf("\nNni = %e atoms",Nni)
16 d=52.00;//g/mol // atomic mass of chromium
17 NCr=(Cr/d)*b
18 mprintf("\nNCr = %e atoms",NCr)
19 e=95.94;//g/mol //atomic mass of Molybdenum
20 NMo=(Mo/e)*b
21 mprintf("\nNMo = %e atoms",NMo)
```

```
22 f=12.01;//g/mol //atomic mass of Carbon
23 NC=(C/f)*b
24 mprintf("\nNC = %e atoms",NC)
25 //so in a 100-g there shold be
26 Ntotal=NFe+Nni+NCr+NMo+NC
27 mprintf("\nNtotal = %e atoms",Ntotal)
28 //The atomic fraction of each alloying element is
      then
29 XNi=Nni/Ntotal
30 mprintf("\nXNi = %e ",XNi)
31 XCr=NCr/Ntotal
32 mprintf("\nXCr = %e",XCr)
33 XMo=NMo/Ntotal
34 mprintf("\nXMo = %e",XMo)
35 Xc=NC/Ntotal
36 mprintf("\nXc = %e",Xc)
37 XNi=5.19*10^-3;//atoms
38 XCr=5.32*10^-3;//atoms
39 XMo=1.16*10^-3;//atoms
40 //which for a 100000 atom alloy gives
41 h=10^5;//atoms //given
42 NNi=XNi*h
43 mprintf("\nNNi = %i atoms",NNi)
44 NCr=XCr*h
45 mprintf("\nNCr = %i atoms",NCr)
46 NMo=XMo*h
47 mprintf("\nNMo = %i atoms",NMo)
48 Nc=Xc*h
49 mprintf("\nNc = %i atoms",Nc)
```

Scilab code Exa 11.2 Calculate the resulting mass savings for the new model approx

```
1 //Example11.2//
2 pFe=7.87;//Mg/m^3 // Density of iron (From Appendix
      1)
```

```
3  pAl=2.70;//Mg/m^3 // Density of Aluminium (From
       Appendix 1)
4  mFe=25;//kg // resulting mass saving
5  a=1;//Mg // given
6  b=10^3;//kg //given
7  V=(mFe/pFe)*(a/b)
8  mprintf("V = %e m^3",V)
9  //the mass of new aluminium parts would be
10 mAl=pAl*V*(b/a)
11 mprintf("\nmAl = %f kg",mAl)
12 //the resulting mass saving is then
13 m=mFe-mAl
14 mprintf("\nm = %f kg",m)
```

Chapter 12

Ceramics and Glasses

Scilab code Exa 12.1 Calculate the weight fraction of Al2O3 in a mullite refactory

```
1 //Example12.1//
2
3 a=26.98;//amu //atomic mass of Aluminium
4 b=16.00;//amu //atomic mass of Oxygen
5 c=2;//Number of atoms
6 d=3;//Number of atoms
7 Al2O3=(c*a)+(d*b)
8 mprintf("Al2O3 = %f amu",Al2O3)
9 e=28.09;//amu //atomic mass of silicon
10 SiO2=e+(c*b)
11 mprintf("\nSiO2 = %f amu",SiO2)
12 f=(d*Al2O3)/((d*Al2O3)+(c*SiO2))
13 mprintf("\nf = %f",f)
```

Scilab code Exa 12.2 What is the raw material batch formula weight percent of Na2O

```
1 //Example12.2//
2 Na=22.99;//amu //atomic mass of sodium
```

```
O=16.00;//amu //atomic mass of Oxygen
a=2;//Number of atoms
c = 2;
Na2O=c*Na+O
mprintf("Na2O = %f amu",Na2O)
d=3;//Number of atoms
C=12.00;//amu //atomic mass of Carbon
Na2CO3=c*Na+C+d*O
mprintf("\nNa2CO3 = %f amu",Na2CO3)
Ca=40.08;//amu //atomic mass of calcium
CaO=Ca+O
mprintf("\nCaO = %f amu",CaO)
CaCO3=Ca+C+d*O
mprintf("\nCaCO3 = %f amu",CaCO3)
a1=150;//Kg //kilogram
Na2Co=a1*(Na2CO3/Na2O)
mprintf("\nNa2Co = %i kg",Na2Co)
b=100;//kg //kilogram
CaCo=b*(CaCO3/CaO)
mprintf("\nCaCo = %i kg",CaCo)
mprintf("\nSio2 required = 750Kg")
SiO2=750;//kg //Kiligram
wt1=(Na2Co/(Na2Co+CaCo+SiO2))*100
mprintf("\nwt1 = %f wt percent Na2CO3",wt1)
wt2=(CaCo/(Na2Co+CaCo+SiO2))*100
mprintf("\nwt2 = %f wt percent CaCO3",wt2)
wt3=SiO2/(Na2Co+CaCo+SiO2)*100
mprintf("\nwt3 = %f wt percent SiO2",wt3)
```

Scilab code Exa 12.3 What would be the composition in weight percent of a glass ce

```
//Example12.3//
Li=6.94;//amu //atomic mass of Lithium
O=16.00;//amu //atomic mass of Oxygen
a=2;//Number of atoms
```

```
5  Li02=a*Li+O
6  mprintf("LiO2 = %f amu",Li02)
7  Al=26.98;//amu
8  b=3;//Number of atoms
9  Al2O3=a*Al+b*O
10 mprintf("\nAl2O3 = %f amu",Al2O3)
11 Si=28.09;//amu //atomic mass of Silicon
12 Si02=Si+a*O
13 mprintf("\nSiO2 = %f amu",Si02)
14 g=4;//given
15 wt1=(Li02)/(Li02+Al2O3+g*Si02 )*100
16 mprintf("\nwt1 = %f percent",wt1)
17 wt2=Al2O3/(Li02+Al2O3+g*Si02 )*100
18 mprintf("\nwt2 = %f percent",wt2)
19 wt3=(g*Si02)/(Li02+Al2O3+g*Si02 )*100
20 mprintf("\nwt3 = %f perecent ",wt3)
```

Scilab code Exa 12.4 In firing 5kg of kaolite Al2 Si2O5 OH4 in a laboratory furnac

```
1  //Example12.4//
2  Al=26.98;//amu //atomic mass of Aluminium
3  O=16.00;//amu //atomic mass of Oxygen
4  Si=28.09;//amu //atomic mass of Silicon
5  H=1.008;//amu //atomic mass of Hydrogen
6  i=2;//Number of atoms
7  j=3;//Number of atoms
8  m1=(i*Al+j*O)+i*(Si+i*O)+i*(i*H+O)
9  mprintf("m1 = %f amu",m1)
10 m2=i*(i*H+O)//amu
11 mprintf("\nm2 = %f amu",m2)
12 //As a result the mass of H2O driven off will be
13 k=5;//kg //Kilograms
14 mH2O=(m2/m1)*k
15 mprintf("\nmH2O = %f kg",mH2O)
16 j=10^3;//g //As 1Kg = 10^3grams
```

```
17 m3=mH2O*j
18 mprintf("   = %i  g  ",m3)
```

Chapter 13

Polymers

Scilab code Exa 13.1 What is the degree of polymerization n of the average polyeth

```
1 //Example 13.1//
2
3 a=25000;//amu //average molecular weight of
    polyethylene
4 C=12.01;//amu //atomic mass of carbon //(From
    Appendix)
5 H=1.008;//amu // atomic mass of Hydrogen ////(From
    Appendix)
6 b=2;//number of atoms
7 d=4;//number of atoms
8 n=a/((b*C)+(d*H))
9 mprintf("n = %i ",n)
```

Scilab code Exa 13.2 How much H2O2 must be added to ethylene to yield an average d

```
1 //Example13.2//
2
3 H=1.008;//amu //atomic mass of Hydrogen //(From
    Appendix 1)
```

```
4 O=16.00;//amu //atomic mass of Oxygen //(From
    Appendix 1)
5 C=12.01;//amu //atomic mass of carbon ////(From
    Appendix 1)
6 a=2;//Number of atoms
7 b=4;//Number of atoms
8 d=750;//average degree of polymerization
9 H2O2=((a*H)+(a*O))/(d*((a*C)+(b*H)))*100
10 mprintf("H2O2 = %f wt percent",H2O2)
```

Scilab code Exa 13.3 Determine the extended lenght of an average molecule

```
1 //Example 13.3//
2
3 l=0.154//nm //length of a single bond
4 n=750;// number of bonds
5 L=l*sqrt(2*n)
6 mprintf("L = %f nm",L)
7 a=109.5;//degree
8 b=2;//given
9 Le=2*n*l*sind(a/b)
10 mprintf("\nLe = %i nm",Le)
```

Scilab code Exa 13.4 What is the maximum fraction of cross link sites that could b

```
1 //Example 13.4//
2 S=32.06;//amu //atomic mass of sulphur //(From
    Appendix 1)
3 C=12.01;//amu //atomic mass of carbon //(From
    Appendix 1)
4 H=1.008;//amu //atomic mass of hydrogen //(From
    Appendix 1)
5 a=5;//Number of atoms
```

```
6  b=8;//Number of atoms
7  ms=S/((a*C)+(b*H))*100
8  mprintf("ms = %f ",ms)
9  c=20;//g //amount of sulphur added
10 fr=c/ms
11 mprintf("\nfr = %f ",fr)
```

Scilab code Exa 13.5 What is the mole fraction of each component

```
1  //Example13.5//
2
3  a=33.3;//g // of each components (acrylonitrile,
       butadiene, and sytrene)
4  C=12.01;//amu //atomic mass of carbon //(From
       Appendix 1)
5  H=1.008;//amu //atomic mass of hydrogen //(From
       Appendix 1)
6  N=14.01;//amu //atomic mass of Nitrogen //(From
       Appendix 1)
7  b=3;//Number of atoms
8  A=a/((b*C)+(b*H)+(N))
9  mprintf("A = %f mol",A)
10 c=4;//Number of atoms
11 d=6;//Number of atoms
12 B=a/((c*C)+(d*H))
13 mprintf("\nB = %f mol",B)
14 d=8;//Number of atoms
15 S=a/((d*C)+(d*H))
16 mprintf("\nS = %f mol",S)
17 fA=A/(A+B+S)
18 mprintf("\nfA = %f ",fA)
19 fB=B/(A+B+S)
20 mprintf("\nfB = %f",fB)
21 fS=S/(A+B+S)
22 mprintf("\nfS = %f",fS)
```

Scilab code Exa 13.6 What would be the molecular weight of a 10 cm 3 cylinder of t

```
1 //Example 13.6//
2 C=12.01;//amu //atomic mass of carbon //(From
    Appendix 1)
3 H=1.008;//amu //atomic mass of hydrogen //(From
    Appendix 1)
4 O=16.00;//amu //atomic mass of oxygen //(From
    Appendix 1)
5 a=6;//Number of atoms
6 b=2;//Number of atom
7 mw=((a*C)+(a*H)+O)+1.5*(C+(b*H)+O)-1.5*((b*H)+O)
8 mprintf("mw = %f g  (Answer is not mentioned in the
    texbook)",mw)
9 //the mass of the polymer i question is
10 p=1.4;//g/cm^3
11 V=10;//cm^3
12 m=p*V
13 mprintf("\nm = %i g",m)
14 //Therefore the numbers of mers in the cylinder is
15 c=0.6023*10^24;//mers //Avogardo's Number
16 n1=m/(mw/c)
17 mprintf("\nn1 = %e mers",n1)
18 //which gives the molecular weight
19 wt=n1*mw
20 mprintf("\nwt = %e amu",wt)
```

Scilab code Exa 13.7 Calculate the density of this engineering polymer

```
1 //Example 13.7//
2
```

```
3 //For 1Kg =of final product
4 a=0.33;//wt % //glass fiber
5 b=1;//kg //kilogram
6 p=a*b
7 mprintf("p = %f kg glass",p)
8 p1=b-a
9 mprintf("\n p1 = %f kg nylon 66",p1)
10 //The total volume of the product
11 mn=0.67;//kg //given
12 mg=0.33;//kg//given
13 pn=1.14;//Mg/m^3 //density of nylon 66
14 pg=2.54;//Mg/m^3 //density of reinforcing glass
15 c=1;//Mg //Milligram
16 d=1000;//kg //given
17 Vp=((mn/pn)+(mg/pg))*(c/d)
18 mprintf("\nVp = %e m^3",Vp)
19 //The over all density of the final product is then
20 p=(c/Vp)*(c/d)
21 mprintf("\np = %f Mg/m^3",p)
```

Scilab code Exa 13.8 Calculate the resulting percentage change in degree of polyme

```
1 //Example 13.8//
2
3 //There is one H2O2 molecule (=two OH groups) per
    polyethylene molecule For 0.15 wt%H2O2
4 C=12.01;//amu //atomic mass of carbon //(From
    Appendix 1)
5 H=1.008;//amu //atomic mass of hydrogen //(From
    Appendix 1)
6 O=16.00;//amu //atomic mass of oxygen //(From
    Appendix 1)
7 a=2;//Number of atoms
8 b=4;//Number of atoms
9 c=0.15;//wt % H2O2
```

```
10 d=0.16; //wt % H2O2
11 n1=(((a*H)+(a*O))/(((a*C)+(b*H))*c))*100
12 mprintf("n1 = %i ",n1)
13 n2=(((a*H)+(a*O))/(((a*C)+(b*H))*d))*100
14 mprintf("\nn2 = %i ",n2)
15 d=((n2-n1)/n1)*100
16 mprintf("\nd = %f percent",d)
```

Chapter 14

Composites

Scilab code Exa 14.1 Determine the density of the composite

```
1 //Example 14.1//
2
3 //(a)=The mass of each component will be
4 a=1.00;//m^3 //composite
5 b=0.70;//m^3 //Vol % E-glass fibers
6 c=a-b
7 mprintf("c = %f m^3",c)
8 d=2.54;//Mg/m^3 //density Of E-glass
9 mg=d*b
10 mprintf("\nmg = %f Mg",mg)
11 e=1.1;//Mg/m^3 //density of epoxy
12 me=e*c
13 mprintf("\nme = %f Mg",me)
14 w=(mg/(mg+me))*100
15 mprintf("\nw = %f percent",w)
16 //(b)= The density will be given by
17 p=mg+me
18 mprintf("\np = %f Mg/m^3",p)
```

Scilab code Exa 14.2 Calculate its molecular weight for a degree of polymerization

```
//Example 14.2//

C=12.01;//amu // atomic mass of Carbon
H=1.008;//amu //atomic mass of hydrogen
O=16.00;//amu //atomic mass of oxygen
a=200;//degree of polymerization
b=6;//numbers of atoms
e=10;//numbers of atoms
d=5;//numbers of atoms
mw=(a)*(b*C+e*H+d*O)
mprintf("mw = %i g/mol (Answer calculated in the
   texbook is wrong)",mw)
```

Scilab code Exa 14.3 Calculate the total weight percent of CaO plus Al2O3 plus SiO

```
//Example 14.3//
Ca=40.08;//amu //atomic mass of Calcium
O=16.00;//amu //atomic mass of oxygen
Si=28.09;//amu //atomic mass of Silicon
a=2;//Number of atoms
f1=(3*(Ca+O))/(3*(Ca+O)+(Si+a*O))
mprintf("f1 = %f",f1)
b=1;//given
f2=b-f1
mprintf("\nf2= %f",f2)
//Similarly
f3=(2*(Ca+O))/(2*(Ca+O)+(Si+a*O))
mprintf("\nf3= %f",f3)
f4=b-f3
mprintf("\nf4= %f",f4)
Mg=26.98;//amu //atomic mass of magnesium
c=3;//Number of atoms
f5=(3*(Ca+O))/(3*(Ca+O)+(a*Mg+c*O))
```

```
19 mprintf("\nf5= %f",f5)
20 f6=b-f5
21 mprintf("\nf6= %f",f6)
22 Mn=55.85;//amu //atomic mas of Magnese
23 f7=(4*(Ca+O))/((4*(Ca+O))+(a*Mg+c*O)+(a*Mn+c*O))
24 mprintf("\nf7 = %f",f7)
25 Al=26.98;//amu //atomic mass of aluminium
26 f8=((a*Al)+(c*O))/(4*(Ca+O)+(a*Mg+c*O)+(a*Mn+c*O))
27 mprintf("\nf8= %f",f8)
28 //Total mass of CaO
29 mcs=45;//kg
30 mc2s=11;//kg
31 i=8;//kg
32 j=27;//kg
33 mc=(f1*mcs)+(f3*j)+(f5*mc2s)+(f7*i)
34 mprintf("\nmc = %f kg",mc)
35 //Similarly
36 ma=(f6*mc2s)+(f8*i)
37 mprintf("\nma = %f kg",ma)
38 ms=(f2*mcs)+(f4*j)
39 mprintf("\nms = %f kg",ms)
40 t=(mc+ma +ms)
41 mprintf("\nt = %f percentage",t)
```

Scilab code Exa 14.4 Calculate the density of the composite

```
1 //Example 14.4//
2
3 a0=1.0;//m^3 // composite
4 d=a0-a
5 mprintf("d= %f m^3",d)
6 pA=2.70;//Mg/m^3 //density of aluminium (at 20degree
      C)
7 a1=3.97;//Mg/m^3 //density of Al2O3
8 a=0.1;//m^3 //meter //For 1m^3 we shall have 0.1m^3
```

```
    of Al2O3
ma=a1*a
mprintf("\nma = %f Mg",ma)
b=0.9;//m^3 //cubic meter
ma1=pA*b
mprintf("\nma1 = %f Mg",ma1)
pc=(ma+ma1)
mprintf("\npc = %f Mg/m^3",pc)
```

Scilab code Exa 14.5 Calculate the composite modulus for polyester reinforced with

```
//Example 14.5//

Em=6.9*10^3;//MPa //polymeric matrix modulus
Ef=72.4*10^3;//MPa //E- glass -reinforced epoxy
vm=0.4; //volume fractions of matrix and fibers
vf=0.6; //volume fractions of matrix and fibers
Ec=vm*Em+vf*Ef
mprintf("Ec = %e MPa",Ec)
```

Scilab code Exa 14.6 Calculate the thermal conductivity parallel to continuous rei

```
//Example 14.6//
vm=0.4;
km=0.17;//W/(m.K)
vf=0.6;
kf=0.97;//W/(m.K)
kc=vm*km+vf*kf
mprintf("kc = %f W/(m.K)",kc)
```

Scilab code Exa 14.7 Calculate the elastic modulus and thermal conductivity perpen

```
1 //Example 14.7//
2 Em=6.9*10^3;//MPa
3 Ef=72.4*10^3;//MPa
4 vm=0.4;
5 Ef=72.4*10^3;//MPa
6 vf=0.6;
7 km=0.17;//W/(m.k)
8 kf=0.97;//W/(m.k)
9 vm=0.4;
10 vf=0.6;
11 Ec=(Em*Ef)/((vm*Ef)+(vf*Em))
12 mprintf("Ec = %e MPa",Ec)
13 kc=(km*kf)/((vm*kf)+(vf*km))
14 mprintf("\nkc = %f W/(m.k)",kc)
```

Scilab code Exa 14.8 Calculate the value of n for this composite to be used in a c

```
1 //Example 14.8//
2 Ec=366;//MPa // composite modulus
3 El=207;//modulus for Co
4 Eh=704;//modulus for WC Phase
5 vl=0.5;//low modulus phase
6 vh=0.5;// high modulus phase
7 n=1; //given
8 n1=(1/2);//given
9 n2=0.01;//given
10 n3=-0.01;//given
11 n4=-1;//given
12 A=(Ec)^n
13 mprintf("A = %i ",A)
14 B=(vl*(El)^n)+(vh*(Eh)^n)
15 mprintf("  B = %f ",B)
16 C=B/A
```

```
17 mprintf("  C = %f ",C)
18 A1=(Ec)^n1
19 mprintf("\nA1 = %f ",A1)
20 B1=(vl*(El)^n1)+(vh*(Eh)^n1)
21 mprintf("  B1 = %f ",B1)
22 C1=B1/A1
23 mprintf("  C1 = %f ",C1)
24 A2=(Ec)^n2
25 mprintf("\nA2 = %f ",A2)
26 B2=(vl*(El)^n2)+(vh*(Eh)^n2)
27 mprintf("   B2 = %f ",B2)
28 C2=B2/A2
29 mprintf("   C2 = %i ",C2)
30 A3=(Ec)^n3
31 mprintf("\nA3 = %f ",A3)
32 B3=(vl*(El)^n3)+(vh*(Eh)^n3)
33 mprintf("  B3 = %f ",B3)
34 C3=B3/A3
35 mprintf("  C3 = %f ",C3)
36 A4=(Ec)^n4
37 mprintf("\nA4 = %e ",A4)
38 B4=(vl*(El)^n4)+(vh*(Eh)^n4)
39 mprintf("  B4 = %e ",B4)
40 C4=B4/A4
41 mprintf("  C4 = %f ",C4)
42 x=[1 1/2 0.01 -0.01 -1];
43 y=[1.24 1.07 1.00 0.999 1.15];
44 plot2d(x,y, style=1)
45 ylabel("B/A","fontsize",4)
46 //Therefore
47 mprintf("\n n=0")
```

Scilab code Exa 14.9 Calculate the isostrain modulus of epoxy reinforced with 73 3

```
1 //Example 14.9//
```

```
2
3 vm=(1.000-0.733);// volume fractions of matrix //(
    The values of vm  are taken from table 14.10 and
    14.11)
4 Em=6.9*10^3;//MPa //polymeric matrix modulus
5 vf=0.733;//volume fractions of fibers // (The values
    of vf are taken from table 14.10 and 14.11)
6 Ef=72.4*10^3;//MPa//E- glass -reinforced epoxy
7 Ec=(vm*Em)+(vf*Ef)
8 mprintf("Ec = %e MPa",Ec)
9 //for this case  Ec=56*10^3 MPa or
10 a=56;//Mpa(The values are from table 14.12)
11 b=54.9;//(The values  are taken from table 14.12)
12 e=((a-b)/a)*100
13 mprintf("\n e = %f percent",e)
14 mprintf("\n The calculated value comes within 2
    percent of the measured value" )
```

Scilab code Exa 14.10 Calculate the specific strenghts of these two materials

```
1 //Example 14.10//
2 a=175;//Mpa //the tensile strength of pure aluminium
3 b=1.02*10^-1;//kg/mm^2/Mpa
4 c=2.70;//Mg/m^3 //density of aluminium
5 d=10^3;//kg/Mg //given
6 e=1;//m^3 //cubic meter
7 f=10^9;//mm^3 //given
8 sp=(a*b)/(c*d*(e/f))
9 mprintf("sp = %e mm",sp)
10 a1=350;//mm //the tensile strength of the dispersion
    strengthened aluminium
11 b1=1.02*10^-1;//mm//given
12 c1=2.83;//Mg/m^3// density of aluminium
13 g=10^-6;//given
14 s=(a1*b1)/(c1*g)
```

```
15 mprintf("\ns = %e mm",s)
```

Scilab code Exa 14.11 For Type 1 cement what percentage increase in compressive st

```
1 //Example 14.11//
2
3 a=4100;//strength (psi)
4 b=3100;//strength (psi)
5 i1=((a-b)/b)*100
6 mprintf("i1 = %f percent",i1)
```

Chapter 15

Electrical Behavior

Scilab code Exa 15.1 Calculate the conductivity of this alloy

```
1 //Example 15.1//
2
3 V=432*10^-3;//V //Voltage
4 I=10;//A //current
5 R=V/I //Ohm's Law
6 mprintf("R = %e ohm",R)
7 A=0.5*10^-3;//m//Area
8 l=1;//m //length
9 p=(R*(%pi*(A)^2))/l
10 mprintf("\np = %e ohm m",p)
11 s=1/p
12 mprintf("\ns = %e ohm^-1 m^-1",s)
```

Scilab code Exa 15.2 Calculate the density of free electrons in copper at room tem

```
1 //Example15.2//
2 s=58.00*10^6;//ohm^-1 m^-1
3 q=0.16*10^-18;//C
```

```
4 u=3.5*10^-3;//m^2/(V.s)
5 n1=s/(q*u)
6 mprintf("n1 = %e m^-3",n1)
```

Scilab code Exa 15.3 Compare the density of free electrons in copper with the dens

```
1 //Example 15.3//
2
3 pcu=8.93;// g cm^-3 //Density of Copper
4 a=63.55;//amu //atomic mass of copper
5 c=10^6;//cm^3/m^3 //given
6 d=1;//g.atom //given
7 h=0.6023*10^24;//atoms/g.atom //Avogardo's Number
8 p=pcu*c*(d/a)*(h)
9 mprintf("p = %e atoms/m^3",p)
10 a1=104*10^27;//m^-3 //density of free electrons in
    copper at room temperature
11 e=a1/p
12 mprintf("\ne = %f",e)
```

Scilab code Exa 15.4 Calculate the drift velocity of the free electrons in copper

```
1 //Example15.4//
2 u=3.5*10^-3;//m^2/(V.s)
3 E=0.5;//V.m^-1
4 v=u*E
5 mprintf("v = %e m/s",v)
```

Scilab code Exa 15.5 What is the probability of an electron being thermally promot

```
1 //Example 15.5//
2
3 a=5.6;//eV //energy band gap
4 b=2;//ev //given
5 E=a/b
6 //Using T=25 degree C= 298K
7 mprintf("E = %f eV",E)
8 T=298;//K //temperature
9 k=86.2*10^-6;//eV K^-1//Boltzmann's constant
10 c1=(%e^(E/(k*T)))+1
11 //mprintf("c1 = %e ",c1)
12 fE=1/c1
13 mprintf("\n fE = %e ",fE)
```

Scilab code Exa 15.6 What is the probability of an electron space being thermally

```
1 //Example 15.6//
2
3 a=1.107;//eV //conduction band in silicon
4 b=2;//eV//electron volt //Given
5 E=a/b
6 mprintf("E = %f eV",E)
7 k=86.2*10^-6;//eVk^-1 //Boltzmann's constant
8 T=298;//k //kelvin //Temperature
9 c=(%e^(E/(k*T)))+1
10 //mprintf("c = %e ",c)
11 fE=1/c
12 mprintf("\nfE = %e ",fE)
```

Scilab code Exa 15.7 Calculate the conductivity of gold at 200 degree C

```
1 //Example 15.7//
2
```

```
3 prt=24.4*10^-9;//ohm m //room temperature value of
     restivity
4 a=0.0034;//C^-1 //temperature coefficient of
     restivity
5 t=200;// degree C //tempertaure
6 tn=20;//degree C //room temperature
7 p=(prt)*(1+a*(t-tn))
8 mprintf("p = %e ohm m",p)
9 s=1/p
10 mprintf("\ns = %e ohm^-1 m^-1",s)
```

Scilab code Exa 15.8 Estimate the resistivity of copper 0 1 wt percentage silicon

```
1 //Example 15.8//
2 //from the figure
3 //p20,Cu-0.1Si ~23.610^*9 ohm m
4 prt=23.6*10^-9//ohm m //room temperature value of
     restivity
5 a=0.00393;//C^-1//temperature coefficient of
     restivity
6 t=100;//C //temperature
7 tn=20;//C//room temperature
8 p=prt*(1+a*(t-tn))
9 mprintf("p = %e ohm m",p)
```

Scilab code Exa 15.10 What is the critical current density for this thin film conf

```
1 //Example 15.10//
2
3 a=17;//A //current along the long dimension
4 b=1*10^-6;//m  //thin strip with dimension
5 c=1*10^-3;//m //thin strip wide dimension
6 d=a/(b*c)
```

```
7 mprintf("d = %e A/m^2",d)
```

Scilab code Exa 15.11 Calculate the total dipole moment for the tetragonal BaTiO3

```
1 //Example 15.11//
2
3 q=0.16*10^-18;//C/ion //unit charge
4 a=1;//ion
5 b=4;//given
6 c=6*10^-3;//nm
7 d=10^-9;//m/nm
8 Ti=a*b*q*c*d
9 mprintf("Ti = +%e C m",Ti)
10 a1=2;//ions
11 b1=(-2);//given
12 c1=-6*10^-3;//nm
13 O2m=a1*b1*q*c1*d
14 mprintf("\nO2m = +%e C m",O2m)
15 c2=-9*10^-3;//nm
16 O2b=a*b1*q*c2*d
17 mprintf("\nO2b = +%e C m",O2b)
18 Qd1=Ti+O2m+O2b
19 mprintf("\nQd1 = %e C m",Qd1)
20 //(b)
21 //For Cubic BaTiO3, there are not net shift and by ,
    deffinition
22 mprintf("\nQd = 0")
```

Scilab code Exa 15.12 Calculate the polarization for tetragonal BaTiO3

```
1 //Example 15.12//
2
```

```
3 //Using result of sample problem 15.11a and the unit
      cell geometry of figure 15.22
4 Qd=10.56*10^-30;//C m// The tetragonal BaTiO3 unit
     cell
5 V1=0.403*10^-9;//m //length of the tetragonal unit
     cell
6 V2=0.399*10^-9;//m //width of the tetragonal unit
     cell
7 P=Qd/(V1*V2^2)
8 mprintf("P = %f C/m^2",P)
```

Scilab code Exa 15.13 Calculate the fraction of Si atoms that provides conduction

```
1 //Example15.13//
2 pSi=2.33;//g cm^-3 //Density of Silicon
3 a=28.09;//amu //atomic mass of silicon
4 b=10^6;//cm^3/m^3
5 c=1;//g.atom
6 e=0.6023*10^24;//atoms/g.atom //Avogadro's Number
7 p=(pSi*b*(c/a)*e)
8 mprintf("p = %e atoms/m^3",p)
9 ne=14*10^15;//m^-3 //carrier density //(From the
     table 15.5)
10 f=ne/p
11 mprintf("\nf = %e ",f)
```

Scilab code Exa 15.14 Calculate the electrical conductivity parallel to reinforcin

```
1 //Example 15.14//
2 vm=0.5;
3 sim=(35.6*10^6);//ohm^-1 m^-1
4 vf=0.5;
5 sif=(10^-11);//ohm^-1 m^-1
```

```
6  sc=(vm*sim)+(vf*sif)
7  mprintf("sc = %e ohm^-1 m^-1",sc)
```

Chapter 16

Optical Behavior

Scilab code Exa 16.1 Calculate energy of a single photon from the short wavelength

```
1 //Example 16.1//
2
3 l=400*10^-9;//m //meter //wavelength
4 h=(0.6626*10^-33);//J s //Joule-second //Plank's
    constant
5 a=0.2998*10^9;//m/s //speed of light
6 c=(6.242*10^18);//eV/J //1 Coulomb of charge
7 E=((h*a)/l)*c
8 mprintf("E = %f eV",E)
```

Scilab code Exa 16.2 What is the thethac for light passing from silica glass to ai

```
1 //Example 16.2 //
2
3 n=1.458;//Average refractive index of silica glass (
    SiO2)
4 thethac=asind(1/n)
5 mprintf("thethac = %f degree",thethac)
```

Scilab code Exa 16.3 Using Fresnel s formula calculate the reflectance R of a shee

```
1 //Example 16.3//
2
3 n=1.59;// Average refractive index Polystyrene
4 R=((n-1)/(n+1))^2;//Fresnel's formula
5 disp(R)
```

Scilab code Exa 16.4 Compare the reflectance of silica glass with that for pure Pb

```
1 //Example 16.4//
2
3 n=1.458;//Average refractive index Silica Glass (
    SiO2)
4 Rs=(((n-1)/(n+1))^2)//Fresnel's formula
5 mprintf("Rs = %f ",Rs)
6 mprintf("(Instead of equal to sign it is given
    addition  sign in the texbook)")
7 //For PbO
8 n1=2.60;//refractive index of PbO
9 Rp=((n1-1)/(n1+1))^2//Fresnel's formula
10 mprintf("\nRp = %f",Rp)
11 R=Rp/Rs
12 mprintf("\nR = %f",R)
```

Scilab code Exa 16.5 Calculate the range of a magnitude of energy transistion that

```
1 //Example 16.5//
2 h=(0.663*10^-33);//J s //Joule-second//Plank's
    constant
```

```
3 c=(3.00*10^8);//m/s //meter per second //speed of
    light
4 l=400*10^-9;//nm// wavelength
5 a=6.242*10^18;//eV/J //1 Coulomb of charge
6 dEb=(h*c)/l
7 mprintf("dEb = %e V",dEb)
8 dEb1=dEb*a
9 mprintf("\ndEb1 = %f eV  (Answer calculated in the
    textbook is wrong)",dEb1)
10 l1=700*10^-9;//nm //wavelength
11 dEr=(h*c)/l1
12 mprintf("\ndEr %e eV",dEr)
13 dEr1=dEr*a
14 mprintf("\ndEr1= %f eV",dEr1)
15 mprintf("\ndelE range: 2.84*10^-19 to 4.97*10^-19J
    (=1.77 to 4.88 eV)")
```

Scilab code Exa 16.6 Calculate the photon wavelength that corresponds to the GaAs

```
1 //Example 16.6//
2
3 h=0.663*10^-33;//J s //Planck's constant
4 c=0.300*10^9;//m/s //speed of light
5 Eg=1.47;//eV // energy gap for GaAs
6 a=6.242*10^18;//eV/J //1 Coulomb of charge
7 l=(h*c/Eg)*a
8 mprintf("l = %e m",l)
9 mprintf(" = 844nm (As 1nano = 10^-9)")
```

Scilab code Exa 16.7 Calculate the critical angle of incidence thethac in a step i

```
1 //Example 16.7//
2
```

```
3 ncladding=1.460;//index of refraction for cladding
4 ncore=1.470;// index of refraction for glass-fiber
    core
5 thethac=asind(ncladding/ncore)
6 mprintf("The value of ncore taken while calculating
    is ncore=1.479 but in the question the value of
    ncore is given n=1.470")
7 mprintf("\nthethac = %f degree ",thethac)
```

Scilab code Exa 16.8 Calculate maximum photon wavelength necessary to produce an e

```
1 //Example 16.8//
2 h=0.663*10^-33;//J s //Planck's constant
3 c=3.00*10^9;//m/s //speed of light
4 Eg=2.59;//eV //energy gap for CdS
5 a=(6.242*10^18);//eV/J //1 Coulomb of charge
6 l=((h*c)/Eg)*a
7 mprintf("l = %e m",l)
8 mprintf(" = 479nm  (As 1 nano = 10^-9)")
```

Chapter 17

Semiconductor Materials

Scilab code Exa 17.1 If n is the density of conduction electron what is value of n

```
1 //Example 17.1//
2
3 psi=2.33;//g cm^-3 //Density of Silicon
4 a=28.09;//amu //atomic mass of silicon
5 b=10^6;//cm^3/m^3 //given
6 c=1;//g.atom //given
7 d=0.6023*10^24;//atoms/g.atom //Avogadro's Number
8 p=psi*b*(c/a)*d
9 mprintf("p = %e atoms/m^3",p)
10 e=28;//conduction electron
11 f=10^14;//atoms //given
12 n=(e/f)*p
13 mprintf("\nn = %e m^-3",n)
```

Scilab code Exa 17.2 Calculate the conductivity of germanium at 200 degree C

```
1 //Example 17.2//
2
```

```
3 n=23*10^18; //m^-3  //density of conduction electron
4 q=0.16*10^-18;//C //one elementary charge
5 ue=0.364;//m^2/(V.s) //electron mobility of
     germanium
6 uh=0.190;//m^2/(V.s)//hole mobility of germanium
7 si=n*q*(ue+uh)
8 mprintf("si = %f ohm^-1 m^-1",si)
9 Eg=0.66;//eV //band gap
10 k=(86.2*10^-6);//eV/K //Boltzmann constant
11 T=300;//K //absolute temperature
12 s0=si*%e^(Eg/(2*k*T))
13 mprintf("\ns0 = %e ohm^-1 m^-1",s0)
14 //Then
15 T1=473;//K //absolute temperature
16 s2=s0*%e^-(Eg/(2*k*T1))
17 mprintf("\ns2 = %i ohm^-1 m^-1",s2)
```

Scilab code Exa 17.3 What is the band gap Eg

```
1 //Example 17.3//
2
3 T1=293;//K //Temperature
4 T2=373;//K //Temperature
5 k=86.2*10^-6;//eV/K //Boltzmann constant
6 T3=1100;//ohm^-1 m^-1 //conductivity
7 T4=250;//ohm^-1 m^-1 //conductivity
8 Eg=-(2*k*(log(T3/T4)))/((1/T2)-(1/T1))
9 mprintf("Eg = %f eV",Eg)
```

Scilab code Exa 17.4 An extrinsic silicon contains 100 ppb Al by weight What is th

```
1 //Example 17.4//
2
```

```
3 //For 100g of doped silicon there will be
4 b=100;//ppb //Al by weight
5 c=10^9;//given
6 d=100;//g Al
7 a=(b/c)*d
8 mprintf("a = %e g Al",a)
9 e=26.98;//g/g.atom //atomic mass of aluminium
10 Al=a/e
11 mprintf("\nAl = %e g atom",Al)
12 f=28.09;//g/g.atom // atomic mass of Silicon
13 Si=(b-a)/f
14 mprintf("\nSi = %f g atoms",Si)
15 pAl=((Al)/(Si+Al))*100
16 mprintf("\npAl = %e  atomic percent",pAl)
```

Scilab code Exa 17.5 What is the probability of an electron s being thermally prom

```
1 //Example 17.5//
2
3 a=1.107;//eV //band gap
4 b=2;//eV //given
5 c=0.1;//eV //Fermi level shifted upward
6 E=(a/b)-c
7 mprintf("E = %f eV",E)
8 k=86.2*10^-6;//eV k^-1//Boltazmann constant
9 T=298;//K //Temperature
10 fE=1/((%e^(E/(k*T)))+1)
11 mprintf("\nfE = %e ",fE)
```

Scilab code Exa 17.6 Calculate the conductivity at 30 degree C

```
1 //Example 17.6//
2
```

```
3 s=100;//ohm^-1 m^-1 //preexponential constant
4 k=86.2*10^-6;//eV K^-1 //Boltzmann constant
5 T=298;//K //Temperature
6 Eg=1.0;//eV // band gap
7 Ed=0.9;//eV //donor level
8 //AT 25 degree C
9 s0=s*%e^((Eg-Ed)/(k*T))
10 mprintf("s0 = %e ohm^-1 m^-1",s0)
11 //At 30degree C
12 T1=303;//K//temperature
13 s=s0*%e^-((Eg-Ed)/(k*T1))
14 mprintf("\ns = %i ohm^-1 m^-1",s)
```

Scilab code Exa 17.7 Calculate the level of phosphorus doping in ppb by weight

```
1 //Example 17.7//
2
3 s=60;//ohm^-1 m^-1 //extrinsic conductivity
4 q=0.16*10^-18;//C //1 coulomb of charge
5 ue=0.364;//m^2/(V.s) //electron mobility
6 n=s/(q*ue)
7 mprintf("n = %e m^-3",n)
8 a=1.03*10^21;//atomsP/m^3
9 b=30.97;//g P
10 c=0.6023*10^24;//atoms P //Avaogardo's Number
11 d=1;//cm^3 Ge //given
12 e=5.32//g Ge // Density of Germanium
13 f=1;//m^3 //given
14 g=10^6;//cm^3 //given
15 p=a*(b/c)*(d/e)*(f/g)
16 mprintf("\np = %e g P/g Ge",p)
17 j=10^9;//as 10^9= 1 billion
18 i=p*j
19 mprintf("\ni = %f ppb P",i)
20 mprintf("    ( As 10^9 = 1 billion)")
```

Scilab code Exa 17.8 Determine the extrinsic conductivity at 300K

```
1 //Example 17.8//
2
3 a=23*10^18;//m^-3
4 q=0.16*10^-18;//C //1 coulomb of charge
5 b=0.364;//m^2/(V.s)//Electron mobility of germanium
6 c=0.190;//m^2/(V.s) //Hole Mobility of Germanium
7 s300K=a*q*(b+c)
8 mprintf("s300K = %f ohm^-1 m^-1",s300K)
9 Eg=0.66;//V //band gap
10 k=86.2*10^-6;//eV/K //Boltzmann constant
11 T=300;//K //absolute temperature
12 s0=s300K*%e^((Eg)/(2*k*T))
13 mprintf("\ns0 = %e ohm^-1 m^-1",s0)
14 Eg1=-0.66;//eV//band gap
15 i=60;//ohm^-1 m^-1 //extrinsic conductivity
16 j=log(i/s0);// Taking log to remove exponential term
17 //mprintf("j = %f ",j)
18 T1=1/((j*2*k)/Eg1);//(Cross multiply and dividing)
19 mprintf("\nT1 = %i K = 135degree C",T1)
20 //(b)
21 Ed=0.012;//eV
22 T2=373;//K //absolute temperature
23 s1=i*%e^((Ed)/(k*T2))
24 mprintf("\ns1 = %f ohm^-1 m^-1",s1)
25 //At 300K
26 T3=300;//K //absolute temperature
27 s2=s1*%e^-((Ed)/(k*T3))
28 mprintf("\ns2 = %f ohm^-1 m^-1",s2)
```

Scilab code Exa 17.9 Plot the conductivity of the phosphorus doped germanium

```
1  //Example 17.9//
2
3  //Extrinsic data
4  s1=60;//ohm^-1 m^-1 //conduvtivity
5  ln1=log(s1)
6  mprintf("ln1 = %f ohm^-1 m^-1",ln1)
7  t1=373;//K //Temperature
8  T1=1/t1
9  mprintf("\nT1 = %e k^-1",T1)
10 s2=54.8;//ohm^-1 m^-1//conductivity
11 ln2=log(s2)
12 mprintf("\nln2 = %f ohm^-1 m^-1",ln2)
13 t2=300;//K //Temperature
14 T2=1/t2
15 mprintf("\nT2 = %e k^-1",T2)
16
17 //Intrinsic Data
18 s3=60;//ohm^-1 m^-1 //conductivity
19 ln3=log(s3)
20 mprintf("\nln3 = %f ohm^-1 m^-1",ln3)
21 t3=408;//K //Temperature
22 T3=1/t3
23 mprintf("\nT3 = %e K^-1",T3)
24 s4=2.04;//ohm^-1 m^-1 //conductivity
25 ln4=log(s4)
26 mprintf("\nln4 = %f Ohm^-1 m^-1",ln4)
27 t4=300;//K //Temperaure
28 T4=1/t4
29 mprintf("\nT4 = %e K",T4)
30 x=[2.68 3.33 2.45 3.33];
31 y=[4.09 4.00 4.09 0.713];
32 plot2d(x,y, style=1)
33 ylabel("ln sigma (ohm^-1 m^-1)", "fontsize", 4);
34 xlabel("1/T*10^3 (K^-1)", "fontsize", 4 );
```

Scilab code Exa 17.10 Calculate the photon wavelenght necessary to promote an elec

```
1 //Example 17.10//
2
3 //(a)
4 Eg=1.107;//eV //bands gap
5 h=(0.663*10^-33);//J s //Planck's constant
6 c=(3*10^8);//m/s //speed of light
7 q=0.16*10^-18;//J/eV // 1 Coulomb of charge
8 a=10^9;//nm/m //given
9 l=((h*c)/(Eg*q))*a
10 mprintf("  Answer calculated in the texbook is wrong
   ")
11 mprintf("\nl = %i nm",l)
12 //(b)
13 Eg1=0.049;//eV// band gap
14 l1=((h*c)/(Eg1*q))*a
15 mprintf("\nl1 = %i nm",l1)
```

Scilab code Exa 17.11 An intrinsic GaAs semiconductor contains 100 ppb Se by weigh

```
1 //Example 17.11//
2
3 b=100;//g //doped GaAs
4 c=10^9;//ppb Se
5 d=100;//g //given
6 a=(d/c)*b
7 mprintf("a = %e g Se",a)
8 S=78.96;//g/g.atom //atomic mass of selenium
9 Se=a/S
10 mprintf("\nSe = %e g atom",Se)
11 Ga=69.72;//g/mol //atomic mass of gallium
12 As=74.92;//g/mol //atomic mass of arsenic
13 G=(b-a)/(Ga+As)
14 mprintf("\nG = %f mol",G)
```

```
15 m=(Se/(G+Se))*100
16 mprintf("\nm = %e mol percent",m)
```

Scilab code Exa 17.12 Calculate the intrinsic conductivity of GaAs at 50 degree C

```
1 //Example 17.12//
2
3 n=(1.4*10^12);//m^-3 //density of charge carrier
4 q=(0.16*10^-18);//C // Coulomb of Charge
5 ue=0.720;//m^2 /(V s) //Electron mobility of GaAs
6 uh=0.020;//m^2 /(V s) //Hole mobility of GaAs
7 s=n*q*(ue+uh)
8 mprintf("s = %e ohm^-1 m^-1",s)
9 Eg=1.47;//eV //band gap
10 k=86.2*10^-6;//eV/K //Boltzmann constant
11 T=300;//K //absolute temperature
12 s0=s*%e^((Eg)/(2*k*T))
13 mprintf("\ns0 = %e ohm^-1 m^-1 ",s0)
14 T2=323;//k //absolute temperature
15 s50=s0*%e^-((Eg)/(2*k*T2))
16 mprintf("\ns50 = %e ohm^-1 m^-1",s50)
```

Scilab code Exa 17.13 In intrinsic semiconductor CdTe what fraction of the current

```
1 //Example 17.13//
2
3 ue=0.070;//Electron Mobility CdTe (From table 17.5)
4 uh=0.007;//holes Mobility CdTe (From table 17.5)
5 fe=ue/(ue+uh)
6 mprintf("fe = %f ",fe)
7 fh=uh/(ue+uh)
8 mprintf("\nfh = %f ",fh)
```

Scilab code Exa 17.14 What is the effect on density of adding the hydrogen

```
1 //Example 17.14//
2
3 b=1.008;//g //atomic mass of Hydrogen
4 c=28.09;//g //atomic mass of Silicon
5 a=100;//given
6 e=0.2;//given
7 f=0.8;//given
8 a2=f*c //(cross multiplying)
9 //mprintf("a2 = %f ",a2)
10 a3=b*a //(cross multiplication)
11 //mprintf("a3 = %f ",a3)
12 a4=e*b //(cross multiplication)
13 //mprintf("a4 = %f g Si",a4)
14 a5=e*a3//multiplication
15 //mprintf("a5 = %f g Si",a5)
16 x=a5/(a2-a4)
17 mprintf("x = %f g H",x)
18 x1=0.889;//g H
19 x2=a-x1
20 mprintf("\nx2 = %f g Si",x2)
21 a7=2.3; //g cm^-3 //density of pure amporhous
     silicon
22 //the volume occupied by the silicon will be
23 V=x2/a7
24 mprintf("\nV = %f cm^3",V)
25 //Therefore the density of the alloy will be
26 p=a/V
27 mprintf("\np = %f g cm^-3",p)
28 //which is an increase of
29 a1=((p-a7)/(a7))*100
30 mprintf("\na1 = %f percent ",a1)
```

Scilab code Exa 17.15 Calculate the segregation coefficient K in the Si rich regio

```
1 //Example 17.15//
2
3 //(a)
4 y1=1190;// degree C //y1 coordinate of the location
     where the line crosses the y axis.
5 y2=1414;// degree C //y2 coordinate of the location
     where the line crosses the y axis.
6 x1=99.985;;// wt % //composition of Si
7 x2=100; //wt % // composition of Si
8 a=y2-y1;//(subracting y intercept of linear euation)
9 //mprintf("a = %i",a)
10 a1=x2-x1 //(subracting m slope of line of linear
     equation)
11 //mprintf("a1 = %f ",a1)
12 m=a/a1; //(Obtaining m value)
13 mprintf("m = %e ",m)
14 b=y2-m*x2; //(Obtaining b value)
15 mprintf("\nb = %e ",b)
16 y3=1360;//degree C //composition
17 x=(y3-b)/m
18 mprintf("\nx = %f ",x)
19 //The segregation coefficienct is calculated in
     terms of impurity levels
20 Cs=x2-x
21 mprintf("\nCs = %f wt percent Al",Cs)
22 x3=90;//percent //si composition
23 Cl=x2-x3;
24 mprintf("\nCl = %i wt percent Al",Cl)
25 K=Cs/Cl
26 mprintf("\nK = %e ",K)
27
28 //(b) For the liquids line a similar staright line
```

```
    expression take place on the values
a4=y2-y3;//(subracting y intercept of linear euation
    )
//mprintf("a4 = %i",a4)
a5=x2-x3 //(subracting m slope of line of linear
    equation)
//mprintf("a5 = %f ",a5)
m1=a4/a5; //(Obtaining m value)
mprintf("\nm1 = %e ",m1)
b1=y2-m1*x2; //(Obtaining b value)
mprintf("\nb1 = %f ",b1)
//A 99 wt % Si bar will have a liquids temperature
x4=99;//
T=m1*(x4)+b1
mprintf("\nT = %f degree C",T)
//The corresponding solids composition is given by
x5=(T-b)/m
mprintf("\nx1 = %f wt percent Si",x1)
//An alternate composition expression
x5=99.999638;//Wt % Si
c=100;//percent
i=(x2-x5)/c
mprintf("\ni = %e Al",i)
mprintf("\nor 3.62 parts per million Al")
mprintf("\nThese calculations are susceptible to
    round-off errors. Values of m and b in the solidus
     line equation must be carried to several palces"
    )
```

Scilab code Exa 17.16 Calculate the collector current produced by further increasi

```
//Example 17.16//

Ic=5;//mA //Collector Current
Ve=5;//mV // Emitter Voltage
```

```
Ic1=50;//mA //Collector Current
Ve2=25;//mV //Emitter voltage
a=log(Ic1/Ic)//(Taking antilog to remove the
    exponential term)
//mprintf("a = %f mV",a)
b=(Ve2-Ve)//(Subtracting the terms)
//mprintf("b = %i ",b)
B=b/a //(Dividing the terms)
mprintf("B = %f mV ",B)
I0=Ic*%e^-(Ve/B)
mprintf("\n I0 = %f mA",I0)
//Therefore
B1=8.69;//mV //constant
Ve3=50;//mV //emitter voltage
I01=2.81;//mA // collector current
Ic=I01*%e^(Ve3/B1)
mprintf("\nIc = %i mA",Ic)
```

Chapter 18

Magnetic Materials

Scilab code Exa 18.1 Calculate the values of mode B and mode M

```
1 //Example 18.1//
2 ur=1.01;
3 u0=4*%pi*10^-7;//henry/m
4 H=2*10^5;//amperes/m
5 B=ur*u0*H
6 mprintf("B = %f weber/m^2",B)
7 //Using second equality, we obtain
8 M=(ur-1)*(H)
9 mprintf("\nM = %e amperes/m",M)
```

Scilab code Exa 18.3 The following data are obtained for a cunife alloy during the

```
1 //Example18.3//
2
3 x=[6*10^4 1*10^4 0 -1*10^4 -2*10^4 -3*10^4 -4*10^4
    -5*10^4 -6*10^4 -6*10^4 -1e4 0 1e4 2e4 3e4 4e4 5
    e4 6e4]
4 y=[0.65 0.58 0.56 0.53 0.46 0.30 0 -0.44 -0.65 -0.65
     -0.58 -0.56 -0.53 -0.46 -0.30 0 0.44 0.65]
```

```
5 plot2d(x,y, style=1)
6 xlabel("H(10^4 A/m)", "fontsize", 2);
7 ylabel("Br(web/m2");
8 mprintf("(b) The remanent induction Br =0.56 weber/m
    ^2 at (H = 0)")
9 mprintf("\n(c) The coercive field Hc = -4*10^4
    amperes/m (at B= 0)")
```

Scilab code Exa 18.4 Make a similar calculation for nickel ferrite which has a mea

```
1 //Example 18.4//
2
3 n=8;//numbers Ni2+/ unit cell
4 n1=2; //moment of Ni2+
5 m=n*n1
6 mprintf("m = %i ",m)
7 a=18.4;// measured value of nickel ferrite
8 e=((a-m)/a)*100
9 mprintf("\ne = %i percent",e)
```

Scilab code Exa 18.5 What would be the saturation magnetization mode M3 for the ni

```
1 //Example 18.5//
2
3 a=18.4;// measured value of nickel ferrite
4 ub=9.274*10^-24;//A m^2// ampere-meters square //
    Moment
5 v=(0.833*10^-9);//m //meter // volume of unit cell
6 Ms=(a*ub)/v^3
7 mprintf("Ms = %e A/m",Ms)
```

Scilab code Exa 18.6 Calculate the energy loss of that magnet

```
1 //Example18.6//
2
3 a=8.9*10^4;//(amperes/m)(webers/m^2) // Area
4 mprintf("a= %e (amperes.webers)/m^3",a)
5 //one ampere weber is equal to 1joule. The area is
     then a volume density of energy ,or
6 e=8.9*10^4//J/m^3 //energy loss
7 b= 10^-3; //As 1Kilogram = 10^3 gram
8 e1=e*b
9 mprintf("\ne1 = %i kJ/m^3 (per cycle) (As 1Kilogram
     = 10^3 garm)",e1)
```

Scilab code Exa 18.7 Calculate the power of the magnet that is the BH maximum valu

```
1 //Example 18.7//
2
3 y=[0 9 9.2 5.3 0]; //B(webers/m^2)
4 x=[0 0.30 0.46 0.53 0.56]; //(BH(weber A/m^3 = J/m
     ^3)
5 plot2d(x,y, style=1)
6 mprintf("(BH)max ~10*10^3 J/m^3")
7 ylabel("BH*(kJ/m^3)","fontsize",4);
8 xlabel("B(web/m^2)","fontsize",4);
```

Scilab code Exa 18.8 Confirm that Fe3 ion should reside in an octahedral coordinat

```
1 //Example 18.8//
2 r=0.067;//nm
3 R=0.132;//nm
4 ra=r/R
5 disp(ra)
```

Scilab code Exa 18.9 Calculate the magnetic moment of a unit cell of manganese fer

```
1 //Example 18.8//
2
3 //(a)
4 a=8;// magnetic moment/unit cell
5 b=5;//moment of Mn2+
6 m=a*b
7 mprintf("m = %i ",m)
8
9 //(b)
10 c=16;//(number Fe3+/unit cell)
11 d=5;//(moment of Fe3+)
12 m1=-(a*b)+(c*d)
13 mprintf("\nm1 = %i ",m1)
14
15 //(c) A 50:50 mixture will give
16 a1=0.5;//given
17 m2=(a1*m1)+(a1*m1)
18 mprintf("\nm2 = %i ",m2)
```

Chapter 19

Environmental Degradation

Scilab code Exa 19.1 What will be the thickness after 1 day assuming a parabolic g

```
1 //Example 19.1//
2
3 t=0;//time
4 y=100;//nm//thickness of oxide coating
5 c4=1;//given
6 c5=y^2-c4*t;//substituting value in the equation
7 mprintf("c5 = %e nm^2",c5)
8 //For
9 t1=1;//h //hour //time
10 y1=200;//nm //thickness of oxide coating
11 c4=y1^2-c5 //substituting values in the equation
12 mprintf("\nc4 = %e nm^2/h",c4)
13 //Then
14 t2=24;//h//hour //time
15 y2=c4*t2+c5
16 mprintf("\ny2 = %e nm^2",y2)
17 mprintf("\nor y=854nm (=0.854 mew m) ")
```

Scilab code Exa 19.2 Given that the density of Cu2O is 6 00 Mg per cubic meter cal

```
1 //Example19.2//
2
3 a=2; //Number of atoms
4 b=63.55;//amu //atomic mass of copper //(From
     Appendix 1)
5 c=16.00;//amu //atomic mass of Oxygen //(From
     Appendix 1)
6 d=8.93;//density
7 e=6.00;//Mg/m^3 //density of Cu2O
8 R=([(a*b)+c]*d)/(a*b*e);//Pilling-Bedworth
9 disp(R)
```

Scilab code Exa 19.3 In a laboratory demonstration of an ionic concentration corro

```
1 //Example19.3//
2
3 //The current indicates a flow rate of electrons
4 a=10*10^-3;//C/s // coulomb per second
5 b=1;//electron
6 c=0.16*10^-18;//C //1 Coulomb of charge
7 I=a*b/c
8 mprintf("I = %e electrons/s",I)
9
10 //As the oxidation of each iron atom generates two
     electrons
11 d=1;//reaction
12 e=2;//electrons
13 r=I*d/e
14 mprintf("\nr = %e reaction/s",r)
```

Scilab code Exa 19.4 If the electrodes are immersed in 1 molar solutions of their

```
1 //Example 19.4//
```

```
2
3 //(a)
4 mprintf("Inspection of Table 19.2 indicates that
     zinci is anodic to iron. Therefore zinci will be
     corroded")
5
6 //(b)Again using Table 19.2 the voltage will be
7 b=(-0.763);//V //Electrode  potential versus normal
     hydrogen at 25 degree C //(From the table)
8 a=(-0.440);//V ///Electrode  potential versus normal
      hydrogen at 25 degree C
9 voltage=a-b
10 mprintf("\nvoltage = %f V",voltage)
```

Scilab code Exa 19.5 What volume of oxygen gas must be consumed at the cathode to

```
1 //Example 19.5//
2
3 a=100;//g Fe //corrosion
4 b=55.85;//g Fe/g atom Fe // Atomic mass of iron (
     From Appendix 1)
5 c=1/2;//mole O2 //Given
6 d=1;//mole Fe //Given
7 m=(a/b)*(c/d)
8 mprintf("m = %f mole O2",m)
9
10 //Using ideal gas law, we obtain
11 //At STP
12 n=0.895;//mole //number of moles
13 R=8.314;//J/mol K //gas constant
14 T=273;//K //Temperature of the gas
15 a1=1;//atm //atmosphere
16 b1=1;//Pa //Pascal
17 P=9.869*10^-6;//atm // atmosphere //pressure of the
     gas
```

```
18 V=(n*R*T)/(a1*b1/P)
19 mprintf("\n V= %f m^3",V)
```

Scilab code Exa 19.6 Calculate the corresponding pH

```
1 //Example 19.6//
2
3 a=0.000;//V //volt //standard state potential for
     the hydrogen half cell
4 b=(-0.763);//V //volt //standard state potential for
      the zinci half cell
5 V0=a-b
6 mprintf("V0 = %f V",V0)
7 n=2;//As two electrons  are transferred per Zn atom
8 V=0.45;//V //Cell voltage
9 c=(-0.059);//From the formula
10 pH=((V-V0)*n)/(c*n)
11 mprintf("\npH = %f ",pH)
```

Scilab code Exa 19.7 A 2 kg sacrificial anode of magnesium is attached to the hull

```
1 //Example 19.7//
2
3 f1=24.31;//g //atomic mass of magnesium
4 e=0.6023*10^24;//atoms //Avogardo's Number
5 q=0.16*10^-18;// C/electron  //1 coulomb of charge
6 a=2;//kg //Kilogram //sacrificial anode of magnesium
7 b=3;// months //period
8 c=1000;//g //gram
9 d=1;//kg //kilogram
10 f=2;//electrons/atom
11 h=1;//month //period
12 a1=31;//d //days //period
```

```
13 a3=1;//d //days //period
14 b1=24;//h //hours //time
15 b2=1;//h //hours //time
16 c1=3600;//s //seconds //time
17 d1=1;//A //ampere //current
18 e1=1;// C/s //coloumb per second
19 current=(a/b)*(c/d)*(e/f1)*f*q*(h/a1)*(a3/b1)*(b2/c1
   )*(d1/e1)
20 mprintf("current %f A ",current)
```

Scilab code Exa 19.8 Calculate the electrochemical potential of this half cell at

```
1 //Example 19.8//
2
3 b=0.09;//V //constant equal to slope of the
   electrochemical potential plot
4 i=1;//A/m^2 //corresponding current density
5 i0=10^-3// A/m^2 //standard state current density
6 n=b*log10(i/i0)
7 mprintf("n = %f V",n)
8
9 //Giving an electrochemical potential at 1A/m^2 of
10 a=(-0.763);//V //standard state potential for the
   zinci half cell
11 V=a+n
12 mprintf("\nV = %f V",V)
```

Scilab code Exa 19.9 Electromagnetic radiation with photon energies greater than 1

```
1 //Example 19.9//
2
3 h=(0.6626*10^-33);//J s //Joule-second //Planck's
   Constant
```

```
4 c=(0.2998*10^9);//m/s //meters per second //speed of
      light
5 l=400*10^-9;//m //meters // Wavelength
6 a=6.242*10^18;//eV/J //1 Coulomb of charge
7 E=((h*c)/l)*a
8 mprintf("E = %f eV",E)
```

Scilab code Exa 19.10 Estimate the particle size of a wear fragment produced by th

```
1 //Example19.10//
2
3 k=45*10^-3;// wear coefficient
4 P=50;//Kg //Kilograms //Load
5 x=5;//mm //millimeter //distance
6 H=235;//kg/mm^2 //hardness of the surface being worn
      away
7 V=(k*P*x)/(3*H)
8 mprintf("V = %f mm^3",V)
9 //As the volume of a hemisphere is (1/12)*pi*d^3
10 a=12; //volume of hemisphere
11 d=nthroot(((a*V)/%pi),3)
12 mprintf("\nd = %f mm ",d)
```

Scilab code Exa 19.11 Calculate the K alpha and the K beta photon energies used in

```
1 //Example 19.11//
2
3 EK=(-7112);//eV // the innermost electron orbital
     shell
4 EL=(-708);//eV // the innermost electron next shell
5 Eka=abs(EK-EL)
6 mprintf("Eka = %i eV",Eka)
7 EM=(-53);//eV //heavier electrons
```

```
Ekb=abs(EK-EM)
mprintf("\nEkb = %i eV",Ekb)
EKLL=abs(EK-EL)-abs(EL)
mprintf("\nEKLL = %i eV",EKLL)
```

Chapter 20

Materials Selection

Scilab code Exa 20.2 Estimate the annual fuel savings due to the weight reduction

```
1 //Example 20.2//
2 wt=570;//kg// wt savings/aircraft
3 a=50;//airc raft
4 b=830;//1per yr/kg // (fuel/year)/(wt savings)
5 f=wt*b*a
6 mprintf("f = %e l",f)
```

Scilab code Exa 20.3 Given the following data indicate the economic advantage of a

```
1 //Example 20.3//
2 a=1.21;//dollar/kg
3 b=0.70;// fabrication yield rate
4 phenolic=a/b
5 mprintf("phenolic =$ %f /kg ",phenolic)
6 a1=4.30;//dollar/kg
7 b1=0.95;// fabrication yield rate
8 polyester=a1/b1
9 mprintf("\npolyester $%f /kg",polyester)
```

```
10 //Then the net materials cost per part is
11 c=2.9;//g/part
12 d=1;//kg //kilogram
13 e=1000;//g //gram
14 p=phenolic*c*d/e
15 mprintf("\np = $%f /part =0.5cents/part",p)
16 py=polyester*c*d/e
17 mprintf("\npy =$%f /part =1.3cents/part",py)
18 a1=10;//dollar per hour/operator
19 b1=1;//operator
20 c1=35;//s/cycle
21 d1=4;//parts/cycle
22 e1=1;//hour
23 f1=3600;//s //seconds
24 p1=a1*b1*(c1/d1)*(e1/f1)
25 mprintf("\np1 = %f /part  = 2.4cents/part",p1)
26 c2=20;//s/cycle
27 g1=5;//operator
28 py1=a1*(b1/g1)*(c2/d1)*(e1/f1)
29 mprintf("\npy1 =$%f /part =0.3 cents/part",py1)
30 //The total cost (materials+labour)is then
31 a3=0.5;//cents/parts
32 b3=2.4;//cents/parts
33 phenolic1=a3+b3
34 mprintf("\nphenolic1 = %f cents/part",phenolic1)
35 a4=1.3;//cents/part
36 b4=0.3;//cents/part
37 polyester2=(a4+b4);// /part
38 mprintf("\npolyester2 = %f cents/part",polyester2)
39 //the greatly reduced labor cost have given a net
   economic advantage to the polyster
```

Scilab code Exa 20.4 Calculate the K alpha photon energy that would be used in a P

```
1 //Example20.4//
```

```
2
3 Ek=(-7112);//eV //the innermost electron orbital
     shell
4 El=(-708);//ev //the innermost electron next shell
5 Eka=abs(Ek-El)
6 mprintf("Eka = %i eV",Eka)
```