Scilab Textbook Companion for Material Science by S. L. Kakani and A. Kakani[1]

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Book Description

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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 structure and electronic configuration

Scilab code Exa 2.1 Distance of the closest approach alpha particles from the copper nucleus

```
1  //Exam:2.1
2  clc;
3  clear;
4  close;
5  Eg_k=5;//kinetic energy of alpha particles(in MeV)
6  Eg_K=5*(10^6)*1.6*(10^-19);//kinetic energy of alpha
       particles(in J)
7  mv2=2*Eg_K;
8  pi=22/7;
9  phi=180;//firing angle
10 Z=29;//Atomic number
11 e=1.6*(10^-19);//electron charge(in C)
12 Eo=8.85*10^-12;//permittivity of free space
13 d=(Z*e^2/(2*pi*Eo*mv2))*(1+cscd(90))//;
14 disp(d,'distance of the closest approach alpha
      particles from the copper nucleus(in meter)=');
```

Scilab code Exa 2.2 radius and frequency of an electron in the bohr first orbit in hydrogen atom

```
1 //Exam:2.2
2 clc;
3 clear;
4 close;
5 e=1.6*10^(-19);//electron charge(in C)
6 m=9.1*10^(-31);//mass of electron(in Kg)
7 E_o=8.854*10^(-12);//permittivity of free space
8 h=6.625*10^(-34);//Planck constant
9 n=1;//Orbit number
10 Z=1;//atomic number
11 pi=22/7;
12 r_1=(E_o*h^2)/(pi*m*e^2);//first orbit radius of
     hydrogen atom
13 disp(r_1,'first orbit radius of hydrogen atom(in m)=
     ');
14 Freq=m*(Z^2)*(e^4)/(4*(E_o^2)*(n^3)*h^3);//
15 disp(Freq,'Orbital frequency of electron(in Hz)=');
```

Scilab code Exa 2.3 radius of the second bohr orbit in a singly ionized helium atom

```
1 //Exam:2.3
2 clc;
3 clear;
4 close;
5 Z_1=1;//atomic number for hydrogen
6 n_1=1;//first orbit
7 r_1=0.529;//radius of first orbit of electron for
     hydrogen
```

```
8  Z_2=2;//atomic number for helium
9  n_2=2;//second orbit
10 k=r_1*Z_1/n_1;
11 r_2=k*((n_2)^2)/Z_2;//radius of first orbit of
       electron for helium
12 disp(r_2,'radius of the second bohr orbit in a
       singly ionized helium atom(in A)=');
```

Scilab code Exa 2.4 Calculate the unit cell dimensions and atomic diameter

```
1  //Exam:2.4
2  clc;
3  clear;
4  close;
5  n_1=1;//first orbit
6  n_2=2;//second orbit
7  n_3=3;//third orbit
8  //E_1=-13.6*(Z^2)/(1^2);
9  //E_2=-13.6*(Z^2)/(2^2);
10 //E_3=-13.6*(Z^2)/(3^2);
11 //E_3-E_1=-13.6*(Z^2)*(-8/9);
12 //E_2-E_1=-13.6*(Z^2)*(-3/4);
13 E_1=-13.6/(1^2);//energy of electron in the first
       bohr orbit of an atom
14 E_2=-13.6/(2^2);//energy of electron in the second
       bohr orbit of an atom
15 E_3=-13.6/(3^2);//energy of electron in the third
       bohr orbit of an atom
16 disp((E_3-E_1)/(E_2-E_1),'ratio of energy released =
       ');
```

Scilab code Exa 2.5 Calculate the revolutions per second of an electron in the bohr orbit of hydrogen atom

```
1 //Exam:2.5
2 clc;
3 clear;
4 close;
5 m=9.1*10^(-31);//electron mass (in Kg)
6 Z=1;//atomic number
7 e=1.6*10^(-19);//electron charge(in C)
8 E_o=8.25*10^(-12);//permittivity of free space
9 n=1;//first bohr orbit
10 h=6.63*10^(-34);//planck constant
11 R_ps=m*(e^4)/(4*(E_o^2)*(h^3));//number of
   revolutions per second
12 disp(R_ps,'revolutions per second of an electron in
   the bohr orbit of hydrogen atom=');
```

Scilab code Exa 2.6 orbital frequency of an electron in the first bohr orbit in a hydrogen atom

```
1 //Exam:2.6
2 clc;
3 clear;
4 close;
5 n=1;//first bohr orbit
6 Z=1;//atomic number
7 m=9.1*10^(-31);//electron mass in Kg.
8 e=1.6*10^(-19);//electron charge(in C)
9 E_o=8.85*10^(-12);//permittivity of free space
10 h=6.63*10^(-34);//planck constant
11 v_n=m*(Z^2)*(e^4)/(4*(E_o^2)*(h^3)*(n^3));//orbital
   frequency of an electron in the first bohr orbit
   in a hydrogen atom
12 disp(v_n,'orbital frequency of an electron in the
```

```
first bohr orbit in a hydrogen atom(in Hz)=');
```

Scilab code Exa 2.7 kinetic energy potential energy and total energy of an electron

```
1  //Exam:2.7
2  clc;
3  clear;
4  close;
5  m=9.11*10^-31;//mass of electron(in Kg)
6  Z=1;//atomic number
7  n=1;//first bohr orbit
8  E_o=8.854*10^-12;//permittivity of free space
9  h=6.62*10^-34;//planck constant
10 e=1.6*10^-19;//electron charge(in C)
11 E_k=(m*(Z^2)*(e^4))/(8*(E_o^2)*(n^2)*(h^2));//
      Kinetic energy(in joule)
12 E=E_k/e;//Kinetic energy(in eV)
13 E_t=-13.6*(Z^2/n^2);//Total Energy(in eV)
14 E_p=E_t-E;//Potential energy(in eV)
15 disp(E_t,'Total energy(in eV)=');
16 disp(E,'kinetic energy(in eV)=');
17 disp(E_p,'potential energy(in eV)=');
```

Scilab code Exa 2.8 velocity of an electron in hydrogen atom in bohr first orbit

```
1  //Exam:2.8
2  clc;
3  clear;
4  close;
5  h=6.626*10^-34;//planck constant
6  E_o=8.825*10^-12;//permittivity of free space
```

```
7  e=1.6*10^-19;//electron charge(in C)
8  n=1;//first bohr orbit
9  Z=1;//atomic number
10 v=Z*(e^2)/(2*E_o*n*h);//velocity of electron in
      hydrogen atom in bohr first orbit
11 disp(v,'velocity of electron in hydrogen atom in
      bohr first orbit(in meter/sec)=');
```

Scilab code Exa 2.9 principal quantum number and wavelengths of radiation in both energies

```
1  //Exam:2.9
2  clc;
3  clear;
4  close;
5  n_1=1;//electron excited from ground state
6  h=6.62*10^-34;//Planck constant
7  c=3*10^8;//speed of light
8  E_o=8.825*10^-12;//permittivity of free space
9  e=1.6*10^-19;//electron charge(in C)
10 m=9.11*10^-31;//mass of electron(in Kg)
11 E_1=10.2;//energy excites the hydrogen from ground
      level(in eV)
12 K=m*e^4/(8*(E_o^2)*(h^2))//in joule
13 K_e=K/e;//in eV
14 //E_1=K_e*((1/n_1^2)-(1/n^2))
15 //1/(n^2)=1/(n_1^2)-E_1/K_e
16 //n^2=1/(1/(n_1^2)-E_1/K_e)
17 n=(1/(1/(n_1^2)-E_1/K_e))^(1/2);//principal quntum
      number when 10.2 eV energy excites electron
18 disp(ceil(n),'principal quntum number when 10.2 eV
      energy excites electron=');
19 W_1=h*c/(E_1*e)*10^10;//wavelength of radiation when
       10.2 eV energy excites electron
20 disp(W_1,'wavelength of radiation when 10.2 eV
```

```
    energy excites electron(in A)=')
21 E_2=12.09;//energy excites the hydrogen from ground
    level(in eV)
22 n_2=(1/(1/(n_1^2)-E_2/K_e))^(1/2);//principal quntum
    number when 12.09 eV energy excites electron
23 W_2=h*c/(E_2*e)*10^10;//wavelength of radiation when
    12.09 eV energy excites electron
24 disp(ceil(n_2),'principal quntum number when 12.09
    eV energy excites electron=')
25 disp(W_2,'wavelength of radiation when 12.09 eV
    energy excites electron(in A)=')
```

Scilab code Exa 2.13 Weight of copper atom and weight of one proton

```
1 //Exam:2.13
2 clc;
3 clear;
4 close;
5 At_w=63.54;//atomic weight of copper
6 N=6.023*10^23;//avogadro's number
7 W_a=At_w/N;//weight of one atom(in gm)
8 W_p=W_a/63;//weight of one proton(in gm)
9 disp(W_a,'weight of one atom(in gm)=');
10 disp(W_p,'weight of one proton(in gm)=');
```

Scilab code Exa 2.15 percentage of Si in Copper silicide

```
1 //Exam:2.15
2 clc;
3 clear;
4 close;
5 Atw_Cu=63.54;//atomic weight of copper
6 Atw_Si=28.09;//atomic weight of silicon
```

```
// 5 atoms of copper working in Cu_5_Si
Tw_Cu=5*Atw_Cu;//total weight of copper used in
   copper silicide
Tw_Si=Atw_Si;//total weight of silicon used in
   copper silicide
Percentage=(Tw_Si/(Tw_Cu+Tw_Si))*100;//percentage of
    Si in Copper silicide
disp(Percentage,'percentage of Si in Copper silicide
   (Cu_5_Si)=')
```

Chapter 3

Crystal Geometry Structure and Defects

Scilab code Exa 3.10 Find the angle Between normals to the planes

```
1 //Exam:3.10
2 clc;
3 clear;
4 close;
5 //Miller indices of plane
6 h_1=1;
7 k_1=1;
8 l_1=1;
9 h_2=1;
10 k_2=2;
11 l_2=1;
12 angle=acosd((h_1*h_2+k_1*k_2+l_1*l_2)/(((h_1^2+k_1
   ^2+l_1^2)^(1/2))*((h_2^2+k_2^2+l_2^2)^(1/2))));
13 disp(angle,'angle Between normals to the planes
   (111) and (121)(in degrees)=');
```

Scilab code Exa 3.11 Determine the packing efficiency and density of sodium chloride

```
1  //Exam:3.11
2  clc;
3  clear;
4  close;
5  r_Na=0.98;//Radius of Na+(in A)
6  r_Cl=1.81;//Radius of Cl-(in A)
7  a=2*(r_Na+r_Cl);//Lattice parameter (in A)
8  pi=22/7;
9  V_i=4*(4/3)*pi*((r_Na^3)+(r_Cl^3));//Volume of ions
       present in unit cell
10 V_u=a^3;//Volume of unit cell
11 Apf=V_i/V_u;//Atomic packing fraction
12 Ef_p=(Apf)*100;//Packing efficiency(in %)
13 AM_sodium=22.99;//Atomic mass of sodium(in amu)
14 AM_chlorine=35.45;//Atomic mass of chlorine(in amu)
15 M_1=4*(AM_sodium+AM_chlorine)*1.66*10^(-27);//Mass
       of the unit cell
16 a_1=a*10^(-10);//Lattice parameter (in meter)
17 V_u1=(a_1)^3;
18 Density=M_1/V_u1;
19 disp(Ef_p,'Packing efficiency of sodium chloride(in
       %)=');
20 disp(Density,'density of sodium chloride(in Kg/m3)='
       );
```

Scilab code Exa 3.12 Calculate the unit cell dimensions and atomic diameter

```
1  //Exam:3.12
2  clc;
3  clear;
4  close;
```

```
5 Density=2.7;//(in g/cm^3)
6 n=4;
7 m=26.98;//atomic weight of Al
8 N_a=6.023*10^(23);//avogadro number
9 a=((n*m/(Density*N_a))^(1/3));//Lattice parameter(in
      Cm)
10 A=a*10^(8);//Lattice parameter(in A)
11 disp(A,'radius(in A)=');
12 r=A/(2*1.414);//radius for fcp structure
13 disp(2*r,'Diameter(in A)=');
```

Scilab code Exa 3.13 Calculate the interplaner distance

```
1 //Exam:3.13
2 clc;
3 clear;
4 close;
5 r=1.245;//radius of nickel (in A)
6 a=4*r/(2)^(1/2);//Lattice constant(in A)
7 //Miller indices of plane 200
8 h_1=2;
9 k_1=0;
10 l_1=0;
11 //Miller indices of plane 111
12 h_2=1;
13 k_2=1;
14 l_2=1;
15 d_200=a/((h_1^2)+(k_1^2)+(l_1^2))^(1/2);
16 d_111=a/((h_2^2)+(k_2^2)+(l_2^2))^(1/2);
17 disp(d_200,'interplaner distance of (200) plane of
      nickel crystal(in A)=');
18 disp(d_111,'interplaner distance of (111) plane of
      nickel crystal(in A)=');
```

Scilab code Exa 3.14 Find the number of atoms per mm2

```
1 //Exam:3.14
2 clc;
3 clear;
4 close;
5 a=3.03*10^(-7);//lattice constant(in mm)
6 N_100=1/(a^2);//Number of atoms in the (100) plane
    of a simple cubic structure
7 N_110=0.707/(a^2);//Number of atoms in the (110)
    plane of a simple cubic structure
8 N_111=0.58/(a^2);//Number of atoms in the (111)
    plane of a simple cubic structure
9 disp(N_100,'Number of atoms in the (100) plane of a
    simple cubic structure(in per mm^2)=');
10 disp(N_110,'Number of atoms in the (110) plane of a
    simple cubic structure(in per mm^2)=');
11 disp(N_111,'Number of atoms in the (111) plane of a
    simple cubic structure(in per mm^2)=');
```

Scilab code Exa 3.15 Determine the planer density of Ni

```
1 //Exam:3.15
2 clc;
3 clear;
4 close;
5 r=1.245*10^(-7);//Radius of the Ni atom(in mm)
6 NA_100=1+(1/4)*4;//Numbers of atom in (100) plane
7 a=4*r/(2)^(1/2);//Lattice constant(in mm)
8 Area=a^2;
9 P_density=NA_100/Area;
```

```
10 disp(P_density,'the planer density of Ni (in atoms
     per mm^2)=');
```

Scilab code Exa 3.16 Calculate the planar atomic densities of planes

```
1  //Exam:3.16
2  clc;
3  clear;
4  close;
5  N_a1=4*(1/4)+1;//Number of atoms contained in (100)
     plane
6  r=1.75*10^(-7);//radius of lead atom (in mm)
7  a_1=2*2^(1/2)*r;//edge of unit  cell in case of
     (100) plane
8  PD_100=N_a1/(a_1^2);//Planar density of plane (100)
9  N_a2=4*(1/4)+2*(1/2);//Number of atoms contained in
     (110) plane
10 a_21=4*r;//top edge of the plane (110)
11 a_22=2*2^(1/2)*r;//vertical edge of the plane (110)
12 PD_110=N_a2/(a_21*a_22);//Planar density of plane
     (110)
13 N_a3=3*(1/6)+3/2;//Number of atom contained in (111)
      plane
14 Ar_111=4*(3^(1/2))*r^2;//area of (111) plane
15 PD_111=N_a3/Ar_111;//Planar density of plane (111)
16 disp(PD_100,'Planar density of plane 100(in atoms/mm
     ^2)=');
17 disp(PD_110,'Planar density of plane 110(in atoms/mm
     ^2)=');
18 disp(PD_111,'Planar density of plane 111(in atoms/mm
     ^2)=');
```

Scilab code Exa 3.17 Calculate the linear atomic densities of planes

```
1  //Exam:3.17
2  clc;
3  clear;
4  close;
5  N_a1=(1/2)+1+(1/2);//Number of diameters of atom
       along (110) direction
6  a=3.61*10^(-7);//lattice constant of copper in mm
7  L_d1=2^(1/2)*a;//length of the face diagonal in case
       of (110) direction
8  p_110=N_a1/L_d1;//linear atomic density along (110)
       of copper crystal lattice(in atoms/mm)
9  N_a2=(1/2)+(1/2);//Number of diameters of atom along
       (111) direction
10 L_d2=3^(1/2)*a;//length of the face diagonal in case
       of (111) direction
11 p_111=N_a2/L_d2;//linear atomic density along (110)
       of copper crystal lattice(in atoms/mm)
12 disp(p_110,'linear atomic density along (110) of
       copper crystal lattice(in atoms/mm)=');
13 disp(p_111,'linear atomic density along (111) of
       copper crystal lattice(in atoms/mm)=');
```

Scilab code Exa 3.18 Find lattice constant

```
1  //Exam:3.18
2  clc;
3  clear;
4  close;
5  A=55.8;//atomic weight of Fe
6  n=2;//number of atoms per unit cell
7  N=6.02*10^(26);//Avogadro's number
8  p=7.87*10^3;//density of Fe(in kg/m^3)
9  a=((A*n/(N*p))^(1/3))*10^10;//Value of lattice
       constant
10 disp(a,'Value of lattice constant(in A)=');
```

Scilab code Exa 3.19 Find the numbers of atoms per unit cell

```
1 //Exam:3.19
2 clc;
3 clear;
4 close;
5 a=2.9*10^(-10);//lattice parameter(in m)
6 A=55.8;//atomic weight of Fe
7 N=6.02*10^(26);//Avogadro's number
8 p=7.87*10^3;//density of Fe(in kg/m^3
9 n=(a^3)*N*p/A;//Numbers of atoms per unit cell
10 disp(floor(n),'Numbers of atoms per unit cell=');
```

Scilab code Exa 3.20 Calculate the line energy of disslocation in bcc iron

```
1 //Exam:3.20
2 clc;
3 clear;
4 close;
5 a=2.87*10^(-10);//lattice parameter for bcc iron
6 b=a*(3^(1/2))/2;//Magnitude of burgers vector
7 u=80*10^9;//shear modulus
8 E=(1/2)*u*b^2;//line energy of disslocation
9 disp(E,'line energy of disslocation(in J/m)=');
```

Scilab code Exa 3.22 Calculate the number of vacancies

```
1 //Exam:3.22
2 clc;
```

```
clear;
close;
N=6.023*10^23;//avogadro number
T=1000;//absolute temperature
R=8.314;//constant
H_f=100*1000;//enthalpy of formation of vacancies(in
    J/mol)
n=N*exp(-(H_f)/(R*T));//number of vacancies created
   during heating(in per mol)
V=5.5*10^(-6);//volume of 1 mole of the crystal in m
   ^3
n_1=n/V;//number of vacancies created during heating
   (in per m^3)
disp(n_1,'number of vacancies created during heating
   (in per m^3)=');
```

Scilab code Exa 3.23 Calculate the surface energy of copper

```
//Exam:3.23
clc;
clear;
close;
//bond energy per atom of copper=bond energy per
   bond*numbers of bond per atom*(1/2)
A=56.4*1000;//
N=6.023*10^23;//avogadro number
n_1=12;//numbers of bond per atom
n_2=3;//bonds broken at the surface
E=A*n_1/(2*N);//Energy of total bonds
E_b=E*(n_2/n_1);//Energy of broken bonds on surface
disp(E_b,'E_b');
n_a=1.77*10^19;//no. of atoms on {111} planes in
   copper(in m^-2)
E_c=n_a*E_b;//Surface energy (enthalpy) of copper
disp(E_c,'Surface energy (enthalpy) of copper(in J/m
```

```
^2)=');
```

Scilab code Exa 3.24 Calculate the equilibrium concentration of vacancies in aluminium

```
1  //Exam:3.24
2  clc;
3  clear;
4  close;
5  H_f=68*1000;//enthalpy of formation of vacancies(in
       J/mol)
6  T_1=0;//temp (in K)
7  T_2=300;//temp (in K)
8  R=8.314;//constant
9  n=exp(-H_f/(R*T_2));//equilibrium concentration of
       vacancies in aluminium at 300 K
10 disp(n,'equilibrium concentration of vacancies in
       aluminium at 300 K=');
```

Scilab code Exa 3.25 Determine the interplanar spacing

```
1  //Exam:3.25
2  clc;
3  clear;
4  close;
5  Wavelength=1.54*10^(-10);//in meter
6  Angle=20.3;//in degree
7  n=1;//First order
8  d=Wavelength*n/(2*sind(Angle));//the interplanar
       spacing(in Meter)
9  disp(d/(10^-10),'the interplanar spacing between
       atomic plane(in A)=');
```

Scilab code Exa 3.26 Calculate the size of unit cell

```
1 //Exam:3.26
2 clc;
3 clear;
4 close;
5 wavelength=0.58;//in Angstrom
6 angle=9.5;//in degree
7 n=1;//First order
8 d_200=wavelength*n/(2*sind(angle));//interplanar
    spacing(in Angstrom)
9 //Miller indices of plane
10 h=2;
11 k=0;
12 l=0;
13 a=d_200*(h^2+k^2+l^2)^(1/2);//Size of unit cell(in
    Angstrom)
14 disp(a,'Size of unit cell(in Angstrom)=');
```

Scilab code Exa 3.27 Calculate the Bragg angle

```
1 //Exam:3.27
2 clc;
3 clear;
4 close;
5 //Miller indices of plane
6 h=1;
7 k=1;
8 l=1;
9 wavelength=0.54;//in angstrom
10 a=3.57;//size of a cube
11 n=1;
```

```
12 d_111=a/(h^2+k^2+l^2)^(1/2);//interplanar spacing(in
       Angstrom)
13 angle=asind(n*wavelength/(2*d_111));
14 disp(angle,'Bragg angle(in degree)=');
```

Scilab code Exa 3.28 Calculate the bragg reflection index

```
1 //Exam:3.28
2 clc;
3 clear;
4 close;
5 d=1.181;//
6 wavelength=1.540;//in angstrom
7 angle=90;//in degree
8 n=2*d*sind(angle)/(wavelength);//the bragg
     reflection index
9 disp(n,'bragg reflection index for BCC crystal=');
```

Scilab code Exa 3.29 Calculate the angle for 3rd order reflection

```
1 //Exam:3.29
2 clc;
3 clear;
4 close;
5 n_1=1;//1st order reflection index
6 angle_1=10;//1st order reflection angle
7 n_3=3;//3rd order reflection index
8 //sind(angle_1)/sind(angle_3)=n_1/n_3
9 angle_3=asind(n_3*sind(angle_1)/n_1);//
10 disp(angle_3,'3rd order reflection angle=')
```

Scilab code Exa 3.30 Obtain the interplanar spacing and miller indices of the reflection plane

```
1  //Exam:3.30
2  clc;
3  clear;
4  close;
5  angle=20.3;//in degree
6  wavelength=1.54;//in angstrom
7  n=1;
8  a=3.16;//lattice parameter in angstrom
9  d=n*wavelength/(2*sind(angle));//interplanar spacing
10 M_indices=a^2/(d^2);
11 disp(d,'interplanar spacing of reflection plane');
12 disp(floor(M_indices),'miller indices of the
       reflection plane');
13 disp((101),(110),(011));
```

Scilab code Exa 3.31 Determine interatomic spacing

```
1  //Exam:3.31
2  clc;
3  clear;
4  close;
5  //Miller indices of plane
6  n=1;
7  h=1;
8  k=1;
9  l=1;
10 angle=30;//in degree
11 wavelength=2;//in angstrom
12 d=n*wavelength/(2*sind(angle));//interplanar spacing
13 a=d*(h^2+k^2+l^2)^(1/2);//interatomic spacing
14 disp(a,'interatomic spacing(in angstrom)=');
```

Chapter 4

Bonds in solid

Scilab code Exa 4.1 distance at which the dissociation occurs

```
1 //Exam:4.1
2 clc;
3 clear;
4 close;
5 r_o=2.8//interatomic distance in
6 R_o=2.8*10^(-10);//interatomic distance in m
7 u_o=8;//released energy in eV
8 e=1.6*10^(-19);//charge of electron in C
9 U_o=8*e//released energy in Joule
10 A=(5/4)*U_o*(R_o^2);//proportionality constant for
    attraction in J-m2
11 B=A*(R_o^8)/5;//proportionality constant for
    repulsion in J-m2
12 r_c=(110*B/(6*A))^(1/8);//interatomic distance at
    which the dissociation occurs in m
13 F=-(2/r_c^3)*(A-5*B/(r_c^8));//the force required to
     dissociate the molecule in N
14 disp(A,'proportionality constant for attraction (in
    J-m2)=');
15 disp(B,'proportionality constant for repulsion (in J
    -m2)=');
```

```
16 disp(r_c,'interatomic distance at which the
     dissociation occurs (in m)=');
17 disp(F,'the force required to dissociate the
     molecule (in N)=');
```

Scilab code Exa 4.2 Find the repulsive exponent n

```
1  //Exam:4.2
2  clc;
3  clear;
4  close;
5  r_o=3.14;//nearest neighbour equilibrium distance in

6  R_o=3.14*10^(-10);//nearest neighbour equilibrium
     distance in m
7  K=5.747*10^(-11);//compressibility of KCl in m2/N
8  M=1.748;//Madelung constant
9  pi=22/7;
10 E_o=8.854*10^(-12);
11 q=1.6*10^(-19);//electron charge
12 n=1+18*(R_o^4)*4*pi*E_o/(K*M*q^2);
13 disp(n,'repulsive exponent n=');
```

Scilab code Exa 4.3 Find the radius of Cl ion

```
1  //Exam:4.3
2  clc;
3  clear;
4  close;
5  F_1=3.02*10^(-9);//force of attraction b/w ions of
     Na+ and Cl-
6  Z_1=+1;
7  Z_2=-1;
```

```
e=1.6*10^(-19);
E_o=8.854*10^-12;
pi=22/7;
r_Na=0.95;//ionic radius of Na+ ion
r=(-Z_1*Z_2*e^2/(4*pi*E_o*F_1))^(1/2);//Radius of
    ion in meter
R=r/10^(-10);//Radius of ion in Angstrom
r_Cl=(R-r_Na);//Radius of Cl- ion in Angstrom
disp(r_Cl,'Ionic Radius of Cl- ion (in Angstrom)=');
```

Scilab code Exa 4.4 force of attraction between ions

```
//Exam:4.4
clc;
clear;
close;
Z_1=+2;
Z_2=-2;
r_Mg=0.65;//radius of Mg++ ion
r_S=1.84;//radius of S-- ion
r=r_Mg+r_S;//net radius(in Angstrom)
R=r*10^(-10);//net radius(in meter)
e=1.6*10^(-19);
E_o=8.854*10^-12;
pi=22/7;
F=-Z_1*Z_2*e^2/(4*pi*E_o*R^2);//force of attraction
    between ions(in Newton)
disp(F,'force of attraction between ions(in Newton)=
    ');
```

Scilab code Exa 4.5 How much net energy is spent in the process

```
//Exam:4.5
```

```
2 clc;
3 clear;
4 close;
5 //Na atom requires +5.14 eV of energy. When this
    electron is transferred to a vacant position, it
    gives back   4.02 eV of energy
6 E_1=+5.14;//in eV
7 E_2=-4.02;//in eV
8 NET_energy=E_1+E_2;//in eV
9 disp(NET_energy,'Net spent energy in whole process(
    in eV)=')
```

Scilab code Exa 4.6 Estimate the fraction of hydrogen bonds that are broken when ice melts

```
1 //Exam:4.6
2 clc;
3 clear;
4 close;
5 Enthalpy=6.02;//enthalpy of fusion of ice is 6.02 kJ
    /mol
6 E_h=20.5;//Hydrogen bond energy (in kJ/mol)
7 //There are two moles of hydrogen bonds per mole of
    H2O in ice.
8 H_b=Enthalpy/(2*E_h);//the fraction of hydrogen
    bonds that are broken when ice melts
9 disp(H_b,'fraction of hydrogen bonds that are broken
    when ice melts=')
```

Chapter 5

Electron Theory of Metals

Scilab code Exa 5.1 Evaluate the temperature

```
1  //Exam:5.1
2  clc;
3  clear;
4  close;
5  //The probability that a particular quantum state at
       energy E is filled, is given by
6  //f(E) =1/(1+exp(E-E_f)/kT)
7  e=1.6*10^(-19);//charge on the electron
8  dE=0.5*e;//E-E_f in joule
9  //0.01=1/(1+exp(x))
10 //1+exp(x)=100
11 x=log(99);
12 k=1.38*10^(-23);//constant
13 T=dE/(x*k);//temperature
14 disp(ceil(T),'temperature at which there is one per
      cent probability that a state with an energy 0.5
      eV above the Fermi energy will be occupied by an
      electron(in K)=');
```

Scilab code Exa 5.2 Find the drift velocity of carriers

```
1 //Exam:5.2
2 clc;
3 clear;
4 close;
5 n=10^19;//electrons per m^3
6 V=0.017;//applied voltage
7 d=0.27*10^-2;//distance with material
8 e=1.602*10^-19;//in coulomb
9 m=9.1*10^-31;//mass of an electron(in kg)
10 conductivity=0.01;//in mho.m^-1)
11 E=V/d;//Electric field(in V/m)
12 v=(conductivity*E/(n*e))*10^2;//drift velocity of
    carriers(in meter/sec)
13 disp(v,'drift velocity of carriers(in meter/sec)=');
```

Scilab code Exa 5.3 Find the conductivity of copper at 300K

```
1 //Exam:5.3
2 clc;
3 clear;
4 close;
5 T=300;//Temperature(in Kelevin)
6 t=2*10^-14;//time(in sec)
7 V_c=8.9;//volume of 63.54gm of copper(in cc)
8 Aw_c=63.54;//Atomic weight of copper(in a.m.u)
9 e=1.6*10^(-19);
10 m=9.1*10^-31;
11 N_a=6.023*10^23;//avogadro's number
12 n=(N_a/(Aw_c/V_c))*10^6;//Number of electrons per m
    ^3
13 conductivity=(e^2)*n*t/m;//conductivity of copper at
    300K(in mho/m)
14 disp(conductivity,'conductivity of copper at 300K(in
```

```
mho/m)=');
```

Scilab code Exa 5.4 Find the mobility of condution electron

```
1 //Exam:5.4
2 clc;
3 clear;
4 close;
5 t=10^(-14);//mean free time between the collisions(
    in second)
6 e=1.6*10^-19;
7 m=9.1*10^-31;
8 Mobility=e*t/m;//in m^2/V-s
9 disp(Mobility,'mobility of condution electron(in m
    ^2/V-s)=');
```

Scilab code Exa 5.5 Find the mobility of condution electron and drift velocity

```
1 //Exam:5.5
2 clc;
3 clear;
4 close;
5 n=6*10^23;//conduction electron per m^3
6 conductivity=6.5*10^7;//in mho/m
7 E=1;//electric field intensity (in V/m)
8 e=1.6*10^-19;
9 m=9.1*10^-31;
10 Mobility=conductivity/(n*e);//in m^2/V-s
11 v=Mobility*E;//drift velocity(in m/sec)
12 disp(Mobility,'mobility of condution electron(in m
    ^2/V-s)=');
13 disp(v,'drift velocity(in m/sec)=');
```

Scilab code Exa 5.6 Find the number of free electrons and also calculate mobility of electrons

```
1 //Exam:5.6
2 clc;
3 clear;
4 close;
5 d=10.5;//density of silver(in gm/cc)
6 At_w=107.9;
7 e=1.6*10^-19;
8 conductivity=6.8*10^5;//in mho/centimeter
9 N=6.023*10^23;
10 n=N*d/At_w;//number of free electrons
11 Mobility=conductivity/(n*e);//mobility of electrons(
   in cm^2/V-s);
12 disp(n,'number of free electrons=');
13 disp(Mobility,'mobility of electrons(in cm^2/V-s)=')
   ;
```

Scilab code Exa 5.7 maximum velocity of an electron in a metal and mobility of electrons

```
1 //Exam:5.7
2 clc;
3 clear;
4 close;
5 E_f=3.75;//Fermi energy(in eV)
6 e=1.602*10^-19;
7 W_f=e*E_f;//fermi energy in joules
8 t=10^-14;//mean free time between the collisions(in
   second)
```

```
9  m=9.1*10^-31;//mass of electron
10 v_f=(2*W_f/m)^(1/2);//maximum velocity of an
      electron in a metal(in m/s)
11 mobility=e*t/m;//mobility of electrons(in m^2/V-s)
12 disp(v_f,'maximum velocity of an electron in a metal
      (in m/s)=');
13 disp(mobility,'mobility of electrons(in m^2/V-s)=')
```

Scilab code Exa 5.8 Calculate the velocity of an electrons at fermi level

```
1  //Exam:5.8
2  clc;
3  clear;
4  close;
5  E_f=2.1;//fermi energy(in eV)
6  e=1.602*10^-19;
7  m=9.1*10^-31;
8  W_f=e*E_f;//fermi energy in joules
9  v_f=(2*W_f/m)^(1/2);//velocity of an electrons at
      fermi level(in m/sec)
10 disp(v_f,'velocity of an electrons at fermi level(in
      m/sec)')
```

Scilab code Exa 5.9 Estimate the mean path of free electrons in pure copper

```
1  //Exam:5.9
2  clc;
3  clear;
4  close;
5  t=10^-9;//collision time(in seconds)
6  E_f=7;//fermi energy(in eV)
7  e=1.6*10^-19;
```

```
8  m=9.1*10^-31;
9  W_f=E_f*e;//fermi energy(in joules)
10 v_f=(2*W_f/m)^(1/2);//velocity of an electrons at
       fermi level(in m/sec)
11 P=v_f*t;//Mean free path(in meter)
12 disp(P,'Mean free path(in meter)=')
```

Scilab code Exa 5.10 Find the conductivity of copper

```
1  //Exam:5.10
2  clc;
3  clear;
4  close;
5  N_a=6.023*10^23;
6  V_c=8.9;//volume of 63.54gm of copper(in cc)
7  Aw_c=63.54;//Atomic weight of copper(in a.m.u)
8  n=(N_a/(Aw_c/V_c))*10^6;//Number of electrons per m
       ^3
9  e=1.6*10^-19;
10 m=9.1*10^-31;
11 t=2*10^-14;//collision time
12 conductivity=n*(e^2)*t/m;//conductivity of copper
13 disp(conductivity,'conductivity of copper(in ohm^-1/
       m)=');
```

Chapter 6

Photoelectric Effect

Scilab code Exa 6.1 kinetic energy of electrons ejected from the surface

```
1  //Exam:6.1
2  clc;
3  clear;
4  close;
5  h=6.62*10^-34;
6  c=3*10^8;
7  e=1.6*10^-19;
8  Wavelength_1=2300*10^-10;
9  W=h*c/Wavelength_1;//Work function
10 Wavelength_2=1800*10^-10;
11 E_in=h*c/Wavelength_2;
12 E=E_in-W;//kinetic energy of the ejected electron(in
       Joules)
13 E_1=E/e;//kinetic energy of the ejected electron(in
     eV)
14 disp(E_1,'kinetic energy of the ejected electron(in
     eV)=');
```

Scilab code Exa 6.2 Calculate the threshold frequency and the corresponding wavelength

```
1 //Exam:6.2
2 clc;
3 clear;
4 close;
5 h=6.625*(10^(-34));//Planck's constant(in m2*kg/s)
6 c=3*10^8;//speed of light (in m/s)
7 e=1.602*10^-19;//electron charge(in coulomb)
8 W=2.3;//work (in eV)
9 W_1=W*e;//work (in joules)
10 v_o=W_1/h;//threshold frequency(in Hz)
11 Wavelength=(h*c/W_1)/10^(-10);//Wavelength in
     Angstrom
12 disp(v_o,'threshold frequency(Hz)=');
13 disp(Wavelength,'Wavelength (in Angstrom)=');
```

Scilab code Exa 6.3 Calculate the threshold frequency and the work function of metal

```
1 //Exam:6.3
2 clc;
3 clear;
4 close;
5 h=6.625*(10^(-34));//Planck's constant(in m2*kg/s)
6 c=3*10^8;//speed of light (in m/s)
7 e=1.602*10^-19;//electron charge(in coulomb)
8 wavelength=6800*10^-10;//wavelength of radiation
9 v_o=c/wavelength;//frequency
10 W=h*v_o;//Work function
11 disp(v_o,'threshold frequency(in Hz)=')
12 disp(W,'work function of metal(in joule)=')
```

Scilab code Exa 6.4 Calculate the photons emitted by lamp per second

```
1 //Exam:6.4
2 clc;
3 clear;
4 close;
5 h=6.625*(10^(-34));//Planck's constant(in m2*kg/s)
6 c=3*10^8;//speed of light (in m/s)
7 L_r =150*8/100;//Lamp rating(in joule)
8 wavelength=4500*10^-10;//in meter
9 W=h*c/wavelength;//work function
10 N=L_r/W;//number of photons emitted by lamp per
    second
11 disp(N,'number of photons emitted by lamp per second
    =')
```

Scilab code Exa 6.5 Determine the region of electrons spectrum

```
1 //Exam:6.5
2 clc;
3 clear;
4 close;
5 h=6.6*(10^(-34));//Planck's constant(in m2*kg/s)
6 c=3*10^8;//speed of light (in m/s)
7 e=1.6*10^-19;//electron charge(in coulomb)
8 W=2.24;//work function(in eV)
9 W_1=W*e;//work function(in joule)
10 v=(W_1/h)*10^-10;//frequency
11 wavelength=c/v;//region of electrons spectrum is
    less than(in angstrom)
12 disp(wavelength,'region of electrons spectrum is
    less than(in angstrom)')
```

Scilab code Exa 6.6 Calculate the photons emitted by radio receiver

```
1 //Exam:6.6
2 clc;
3 clear;
4 close;
5 h=6.625*(10^(-34));//Planck's constant(in m2*kg/s)
6 c=3*10^8;//speed of light (in m/s)
7 P_o=10*10^3;//Power of radio receiver (in Watt)
8 v=440*10^3;//Operating frequency
9 E=h*v;//Energy of each electron
10 N=P_o/E;//Number of photons emitted/sec
11 disp(N,'Number of photons emitted/sec by radio
    receiver=')
```

Scilab code Exa 6.7 wavelength of light which can just eject electron from tungsten and from barrium

```
1 //Exam:6.7
2 clc;
3 clear;
4 close;
5 W_t=4.52;//Work function for tungesten(in eV)
6 W_b=2.5;//Work function for barrium(in eV)
7 h=6.62*(10^(-34));//Planck's constant(in m2*kg/s)
8 c=3*10^8;//speed of light (in m/s)
9 e=1.6*10^-19;//electron charge(in coulomb)
10 W_T=W_t*e;//Work function for tungesten(in Joule)
11 W_B=W_b*e;//Work function for barrium(in Joule)
12 Wavelength_T=(h*c/W_T)*10^10;//wavelength of light
    which can just eject electron from tungsten
```

```
13 Wavelength_B=(h*c/W_B)*10^10;//wavelength of light
     which can just eject electron from barrium
14 disp(Wavelength_T,'wavelength of light which can
     just eject electron from tungsten(in Angstrom)=')
15 disp(Wavelength_B,'wavelength of light which can
     just eject electron from barrium(in Angstrom)=')
```

Chapter 7

Diffusion in Solids

Scilab code Exa 7.1 find the time required for carburization

```
1 //Exam:7.1
2 clc;
3 clear;
4 close;
5 D=1.28*10^(-11);//diffusion coefficient of carbon in
      given steel in m2/s
6 c_s=0.9;//Surface concentration of diffusion element
      in the surface
7 c_o=0.2;//Initial uniform concentration of the
    element in the solid
8 c_x=0.4;//Concentration of the diffusingelement at a
      distance x from thesurface
9 x=0.5*10^(-3);//depth from the surface in m
10 //(c_s-c_x)/(c_s-c_o)=erf(x/(2*(D*t)^(1/2)))
11 t=(x/(2*erfinv((c_s-c_x)/(c_s-c_o))*D^(1/2)))^2;//
    time required for carburization(in sec)
12 disp(t,'time required for carburization(in sec)=');
```

Scilab code Exa 7.2 time required

```
1  //Exam:7.2
2  clc;
3  clear;
4  close;
5  D=4*10^(-17);//diffusion coefficient of carbon in
       given steel in m2/s
6  c_s=3*10^26;//Surface concentration of boron atoms
       in the surface
7  c_1=0;//Initial uniform concentration of the element
        in the solid
8  c_x=10^23;//Concentration of the diffusing element
       at a distance x from thesurface
9  x=2*10^(-6);//depth from the surface in m
10 //(c_s-c_x)/(c_s-c_1)=erf(x/(2*(D*t)^(1/2)))
11 a=(erfinv((c_s-c_x)/(c_s-c_1)));
12 disp(a,'==')
13 t=(x^2/(D*4*(2.55)^2));//time required to get a
       boron content of 1023 atoms per m3 at a depth of
       2 micro meter
14 disp(t,'time required to get a boron content of 1023
        atoms per m3 at a depth of 2 micro meter(in sec)
       =');
15 disp((c_s-c_x)/(c_s-c_1));
16 T=(x/(2*(2.55)*D^(1/2)))^2;
17 disp(T,'==')
```

Scilab code Exa 7.3 find the constant of the equation and activation energy

```
1  //Exam:7.3
2  clc;
3  clear;
4  close;
5  t_1=736;//Temperature in  C
6  t_2=782;//Temperature in  C
```

```
T_1=t_1+273;//Temperature in K
T_2=t_2+273;//Temperature in K
D_1=2*10^(-13);//Coefficient of diffusion at T_1 (in
    m2/s)
D_2=5*10^(-13);//Coefficient of diffusion at T_2 (in
    m2/s)
k=1.38*10^(-23);//in J/K
//log(d_1)=log(d_o)-E/(k*T_1)
//log(d_2)=log(d_o)-E/(k*T_2)
E=(log(D_1)-log(D_2))/((1/(k*T_1))-(1/(k*T_2)));//
disp(E,'activation energy(in J)=');
D_o=2*10^(-13)/exp(E/(k*T_1));
disp(D_o,'constant of the equation(in m2/s)=')
t_4=500;//Temperature in  C
T_4=t_4+273;//Temperature in  K
D_4=D_o*exp(E/(k*T_4));//diffusion coefficient at
   500 C
disp(D_4,'diffusion coefficient at 500 C(in m2/s)='
   )
```

Scilab code Exa 7.4 approximate time that will produce same diffussion at 500 C

```
//Exam:7.4
clc;
clear;
close;
D_500=4.8*10^(-14);//Diffusion coefficient for
   copper in aluminimum at 500*C(in m^2/s)
D_600=5.3*10^(-13);//Diffusion coefficient for
   copper in aluminimum at 600*C(in m^2/s)
t_600=10;//time of diffussion at 600*C(in Hours)
//D_500*t_500=D_600*t_600
t_500=D_600*t_600/D_500;//time of diffussion at 500*
   C
```

```
10 disp(t_500,'Time at 500*C that will produce the same
       diffusion as in 600*C(in Hours)=');
```

Chapter 8

Mechanical Properties of Materials and Mechanical Tests

Scilab code Exa 8.1 Determine the fracture strength

```
1  //Exam:8.1
2  clc;
3  clear;
4  close;
5  Y=180*10^9;//Young's modulus of a certain material(
       in N/m^2)
6  E=1.8;//true surface energy (in J/m^2)
7  c=(5/2)*10^-6;//Crack (in meter)
8  pi=3.14;
9  F_strength=(2*Y*E/(pi*c))^(1/2);
10 disp(F_strength*10^-6,'fracture strength(in MN/m^2)=
       ');
```

Scilab code Exa 8.2 true stress and strain with engineering stress and strain

```
1  //Exam:8.2
2  clc;
3  clear;
4  close;
5  d_o=12.7;//tensile test specimen diameter (in mm)
6  d=12;//tensile test specimen diameter after load (in
       mm)
7  P=76*10^3;//load(in N)
8  pi=22/7;
9  A_o=(pi/4)*(d_o^2);//Initial area of cross section(
       in mm^2)
10 A=(pi/4)*(d^2);//area of cross section after load of
       76 kN
11 E_stress=P/A_o;//engineering stress
12 T_stress=P/A;//true stress
13 T_strain=log(A_o/A);//true strain
14 E_strain=exp(T_strain)-1;//engineering strain
15 disp(E_stress,'engineering stress(in N/mm^2)=');
16 disp(T_stress,'true stress(in N/mm^2)=');
17 disp(E_strain,'engineering strain=');
18 disp(T_strain,'true strain=');
```

Scilab code Exa 8.3 Determine the fracture strength

```
1  //Exam:8.3
2  clc;
3  clear;
4  close;
5  Y=210*10^9;//Young's modulus of a certain material(
       in N/m^2)
6  E=10;//true surface energy (in J/m^2)
7  c=(100/2)*10^-6;//Crack (in meter)
8  pi=3.14;
9  F_strength=(2*Y*E/(pi*c))^(1/2);
10 disp(F_strength,'fracture strength(in Newton/m^2)=')
```

;

Scilab code Exa 8.4 Find the resultant elongation

```
1 //Exam:8.4
2 clc;
3 clear;
4 close;
5 l_o=305*10^-3;//length of copper piece(in meter)
6 E=110*10^9;//surface energy
7 stress=276*10^6;//in Pa
8 dl=stress*l_o/E;//resultant elongation(in meter)
9 disp(dl*10^3,'resultant elongation(in mm)=');
```

Scilab code Exa 8.5 Compute the strain hardening exponent

```
1 //Exam:8.5
2 clc;
3 clear;
4 close;
5 T_stress=415;//True stress (in Megapascal)
6 T_strain=0.10;//True strain
7 K=1035;//(in Megapascal)
8 n=(log(T_stress)-log(K))/log(T_strain);//
9 disp(n,'Strain hardening exponent for an alloy=')
```

Chapter 9

Alloys Systems Phase Diagrams and Phase Transformations

Scilab code Exa 9.1 Find the percentage of proeutectoid ferrite

```
1 //Exam:9.1
2 clc;
3 clear;
4 close;
5 //Fulcrum is at 0.5% carbon
6 //from lever rule
7 Pro_f=((0.80-0.5)/(0.80-0.0))*100;// % Proeutectoid
    ferrite
8 Pea_f=100-Pro_f;// % Pearlite ferrite
9 disp(Pro_f,'% Proeutectoid ferrite=');
10 disp(Pea_f,'% Pearlite ferrite=');
```

Scilab code Exa 9.2 Degrees of freedom of a system of two components

```
1 //Exam:9.2
2 clc;
```

```
clear;
close;
N=2;
C=2;
//F=C-P+N
P_1=1;
P_2=2;
P_3=3;
P_4=4;
F_1=C-P_1+N;
F_2=C-P_2+N;
F_3=C-P_3+N;
F_4=C-P_4+N;
disp(F_1,'Degrees of freedom for 1 phase=');
disp(F_2,'Degrees of freedom for 2 phases=');
disp(F_3,'Degrees of freedom for 3 phases=');
disp(F_4,'Degrees of freedom for 4 phases=');
```

Scilab code Exa 9.3 Find the minimum number of components in the system

```
//Exam:9.3
clc;
clear;
close;
P=4;//Number of phases exhibit by a material
F=0;//Minimum degrees of freedom
//modified form of the phase rule F=C-P+1
C=F+P-1;//minimum number of components in the system
disp(C,'the minimum number of components in the
   system=')
```

Chapter 10

Heat Treatment

Scilab code Exa 10.1 Determine the grain diameter of an ASTM Number 8

```
1 //Exam:10.1
2 clc;
3 clear;
4 close;
5 N=8;//ASTM grain size number
6 n=2^(N-1);//Number of grains per inch square at a
    magnification
7 N_1=n*100*100;//Number of grains per inch square
    without magnification
8 N_2=N_1/(25.4)^2;//Number of grains per mm square
    without magnification
9 A_a=1/(N_2);//Average area of each grain(in mm^2)
10 D=(A_a)^(1/2);//Average grain diameter(in mm)
11 disp(D,'Average grain diameter(in mm)=')
```

Chapter 11

Deformation of Materials

Scilab code Exa 11.1 Determine the value of critical resolved shear stress

```
1  //Exam:11.1
2  clc;
3  clear;
4  close;
5  h_1=1;
6  k_1=1;
7  l_1=1;
8  //Miller indices of slip plane
9  h_2=1;
10 k_2=-1;
11 l_2=1;
12 //Miller indices of stress plane
13 h_3=1;
14 k_3=1;
15 l_3=0;
16 //Miller indices of slip direction
17 A=(h_1*h_2+k_1*k_2+l_1*l_2)/(((h_1^2+k_1^2+l_1^2)
      ^(1/2))*((h_2^2+k_2^2+l_2^2)^(1/2)));//Value of
      cos(x) where x =angle between slip plane and
      stress plane
18 B=(h_1*h_3+k_1*k_3+l_1*l_3)/(((h_1^2+k_1^2+l_1^2)
```

```
^(1/2))*((h_3^2+k_3^2+l_3^2)^(1/2)));//Value of
    cos(y) where y =angle between slip direction and
    stress direction
C=(1-A^2)^(1/2);//Value of sin(x)
stress=3.5;//Applied Stress in Mpa
T_cr=stress*A*B*C;//Critical resolved shear stress(
    in MPa)
disp(T_cr,'Critical resolved shear stress(in MPa)=')
    ;
```

Scilab code Exa 11.3 Find the yield stress

```
//Exam:11.3
clc;
clear;
close;
D=0.002;//Grain diameter(in mm)
d=D*10^(-3);//Grain diameter(in m)
K=0.63;//Constant(in MNm^(-3/2))
sigma_i=80;//in MNm^-2
sigma_y=sigma_i+K*d^(-1/2);//Yield stress for a
    polycrystalline alloy
disp(sigma_y,'Yield stress for a polycrystalline
    alloy(in MN/m^2)');
```

Scilab code Exa 11.4 Find the yield stress

```
//Exam:11.4
clc;
clear;
close;
sigma_y1=120;//primary yield strength of
    polycrystalline material(in MN*m^-2)
```

```
sigma_y2=220;//increased yield strength of
    polycrystalline material(in MN*m^-2)
d_1=0.04*10^(-3);//primary grain diameter(in meter)
d_2=0.01*10^(-3);//grain diameter after decreasing(
    in meter)
//sigma_y1=sigma_i+K*(d_1)^(-1/2)
//sigma_y2=sigma_i+K*(d_2)^(-1/2)
//putting the values and solving the equation
K=(220-120)/((d_2^(-1/2))-((d_1^(-1/2))));//constant
    (in MN*m(-3/2))
sigma_i=sigma_y1-K*(d_1)^(-1/2);//in MN*m^-2
d=1/((10^4)*(256/645))^(1/2);//grain diameter for
    grain size ASTM 9(in mm)
D=d*10^(-3);//grain diameter for grain size ASTM 9(
    in meter)
sigma_y=sigma_i+K*(D)^(-1/2);//Yield stress for a
    polycrystalline alloy for grain size ASTM 9(in MN
    *m^-2)
disp(ceil(sigma_y),'Yield stress for a
    polycrystalline alloy for grain size ASTM 9(in MN
    *m^-2)=');
```

Chapter 12

Oxidation and Corrosion

Scilab code Exa 12.1 Find the distance at which magnisium anode capable of giving 2MA

```
1 //Exam:12.1
2 clc;
3 clear;
4 close;
5 D=320*10^-3;//in meter
6 L=1;//in meter
7 A=%pi*D*L;//Surface area in meter^2
8 l=ceil (200/A);
9 disp(l,'the distance at which magnisium anode
    capable of giving 2MA (in meters)=');
```

Scilab code Exa 12.2 Quality of magnesium required per square meter of the hull surface

```
1 //Exam:12.2
2 clc;
3 clear;
```

```
close;
W=0.0243;//1 mole of magnesium weight(in Kg)
C=2*96490;//used charge (in A-s)
A=15*10^(-3);//current density (in A/metre2)
t=10;//time (in years)
T=10*365*24*3600;//time (in sec)
//amount of magnesium required =charge required per m2 of hull surface for a design life of 10 years /(used charge for anode)
Mg_required=W*A*T/C;//magnesium required per square meter of the hull surface for a design life of 10 years
disp(Mg_required,'magnesium required per square meter of the hull surface for a design life of 10 years(in Kg/m2)=');
```

Chapter 13

Thermal and Optical Properties of Materials

Scilab code Exa 13.1 Maximum temperature to which the rod may be heated without exceeding a compressive stress

```
1 //Exam:13.1
2 clc;
3 clear;
4 close;
5 alpha=20*10^(-6);//linear coefficient of thermal
    expansion per C
6 Sigma=-(172);//compressive stress MPa
7 T=20;//Temprature at which rod is stress free(in  C
    )
8 E=100*10^3;//modulus of elasticity (in MPa)
9 T_f=T-(Sigma/(alpha*E));//maximum temperature the
    rod may be heated without exceeding a compressive
     stress of 172 MPa
10 disp(T_f,'maximum temperature(in  C) the rod may be
     heated without exceeding a compressive stress of
     172 MPa=');
```

Chapter 14

Electrical and Magnetic Properties of Materials

Scilab code Exa 14.1 Calculate the resistance of an aluminium wire

```
1 //Exam:14.1
2 clc;
3 clear;
4 close;
5 l=100;//length of wire
6 p=2.66*10^(-8);//resistivity
7 A=3*10^(-6);//cross sectional area
8 R=p*l/A;//resistance of an aluminium wire
9 disp(R,'resistance of an aluminium wire(in Ohm)=');
```

Scilab code Exa 14.2 Resistivity of a copper alloy containing 1 atomic percent nickel and 3 atomic percent silver

```
1 //Exam:14.2
2 clc;
3 clear;
```

```
4 close;
5 R_Cu=1.56;//Resistivity of pure copper(in micro-ohm-
    cm)
6 R_CuNi = 4.06;//Resistivity of Cu containing two
    atomic percent (in micro-ohm-cm)
7 R_Ni=(R_CuNi-R_Cu)/2;//Increase in resistivity due
    to one atomic % Ni
8 R_CuAg= 1.7;//resistivity of copper, containing one
    atomic percent silver (in micro-ohm-cm)
9 R_Ag=R_CuAg-R_Cu;//Increase in resistivity due to
    one atomic % Ag
10 R_CuNiAg=R_Cu+R_Ni+3*R_Ag;//Resistivity of copper
    alloy containing one atomic percent Ni and 3
    atomic percent Ag
11 disp(R_CuNiAg,'Resistivity of copper alloy
    containing one atomic percent Ni and 3 atomic
    percent Ag(in micro-ohm-cm)=')
```

Scilab code Exa 14.3 Find the resistivity due to impurity scattering per percent of Ni in the Cu lattice

```
1 //Exam:14.3
2 clc;
3 clear;
4 close;
5 R_Cu=1.8*10^(-8);//resistivity of pure copper at
    room temperature
6 R_CuNi=7*10^(-8);//resistivity of Cu 4% Ni alloy at
    room temperature
7 R_Ni=(R_CuNi-R_Cu)/4;//resistivity due to Impurity
    scattering per % of Ni
8 disp(R_Ni,'resistivity due to impurity scattering
    per percent of Ni in the Cu lattice(in ohm-meter)
    =')
```

Scilab code Exa 14.4 Calculate the relative dielectric constant of a barium titanate crystal

```
1 //Exam:14.4
2 clc;
3 clear;
4 close;
5 C=10^(-9);//capacitance(in F)
6 d=2*10^(-3);//distance of separation in a parallel
     plate condenser
7 E_o=8.854*10^(-12);//dielectric constant
8 A=(10*10^(-3))*(10*10^(-3));//area of parallel plate
     condenser
9 //C=E_o*E_r*A/d
10 E_r=C*d/(E_o*A);//Relative dielectric constant
11 disp(ceil(E_r),'Relative dielectric constant of a
     barium titanate crystal')
```

Scilab code Exa 14.5 Calculate the polarization

```
1 //Exam:14.5
2 clc;
3 clear;
4 close;
5 q=1.6*10^(-19);//charge (in C)
6 d_1=0.06//shift of the titanium ion from the body
     centre (in    )
7 d_2=0.08//shift of the oxygen anions of the side
     faces (in    )
8 d_3=0.06//shift of the oxygen anions of the top and
     bottom face (in    )
```

```
D_1=d_1*10^(-10);//shift of the titanium ion from
    the body centre (in m)
D_2=d_2*10^(-10);//shift of the oxygen anions of the
    side faces (in m)
D_3=d_3*10^(-10);//shift of the oxygen anions of the
    top and bottom face (in m)
U_1=4*q*D_1;//dipole moment due to two O2  ions on
    the four side faces(in C-m)
U_2=2*q*D_2;//dipole moment due to one O2  on top
    and bottom(in C-m)
U_3=4*q*D_3;//dipole moment due to one Ti4+ ion at
    body centre(in C-m)
U=U_1+U_2+U_3;//Total dipole moment(in C-m)
V=4.03*((3.98)^2)*10^(-30);//volume(in m3)
P=U/V;//polarization the total dipole moments per
    unit volume
disp(P,'polarization(in C/m^2)=');
disp(U,'==')
```

Scilab code Exa 14.6 Find net magnetic moment per iron atom in the crystal

```
//Exam:14.6
clc;
clear;
close;
V=((2.87)^3)*10^(-30)//Volume of unit cell of BCC
    iron (in m^3)
N=2//Number of atoms in the unit cell
M=1750*10^3;//saturation magnetization of BCC Iron A
    /m
M_Net=V*M*(1/N)//net magnetic moment per atom
Bohr_magneton=9.273*10^(-24);//Bohr_magneton (
    magnetic moment) in A/m2
M_moment=M_Net/Bohr_magneton;//The magnetic moment (
```

```
    in units of U_B)
11 disp(M_moment,'The magnetic moment (in units of U_B)
    =');
```

Scilab code Exa 14.7 Calculate the saturation magnetization and the saturation flux density

```
1  //Exam:14.7
2  clc;
3  clear;
4  close;
5  p=8.90*10^6;//density of nickel in gm/m3.
6  N_A=6.023*10^23;//Avogadro s number atoms/mol
7  At_w=58.71;//Atomic weight of Ni in gm/mol
8  N=p*N_A/At_w;//number of atoms/m3
9  U_B=9.273*10^(-24);//Bohr_magneton
10 M_s=0.60*U_B*N;//saturation magnetization
11 pi=22/7;
12 U_o=4*pi*10^(-7);//magnetic constant
13 B_s=U_o*M_s;//Saturation flux density
14 disp(M_s,'the saturation magnetization=');
15 disp(B_s,'Saturation flux density=');
```

Scilab code Exa 14.8 Calculate the saturation magnetization

```
1  //Exam:14.8
2  clc;
3  clear;
4  close;
5  //Each cubic unit cell of ferrous ferric oxide
    contains 8 Fe2+ and 16 Fe3+ ions and
6  n_b=32;//
7  U_B=9.273*10^(-24);//Bohr_magneton
```

```
a=0.839*10^(-9);//the unit cell edge length in m
V=a^3;//volume(in m3)
M_s=n_b*U_B/V;//the saturation magnetization
disp(M_s,'the saturation magnetization=');
```

Scilab code Exa 14.9 Calculate eddy current loss at the normal voltage and frequency

```
//Exam:14.9
clc;
clear;
close;
//hysteresis loss (Ph) and the induced emf loss (Pe)
    are proportional to the frequency
//Pe is proportional to the square of the induced
   emf (Pe)
//Pe + Ph = 750 W (at 25 Hz)
//4Pe + 2Ph = 2300 W(at 50Hz)
//solving equation
P_e=800/2;//induced emf loss
I_d=4*P_e;//The eddy current loss at the normal
   voltage and frequency
disp(I_d,'The eddy current loss at the normal
   voltage and frequency(in W)=');
```

Chapter 15

Semiconductors

Scilab code Exa 15.1 Find the conductivity and resistivity of a pure silicon crystal

```
1 //Exam:15.1
2 clc;
3 clear;
4 close;
5 U_n=1350//mobility of electron in cm2/volt-sec
6 U_h=480//hole mobility in cm2/volt-sec
7 Sigma=1.072*10^10//density of electron hole pair per
      cc at 300 K for a pure silicon crystal
8 e=1.6*10^(-19);//charge on the electron in C
9 Sigma_i=Sigma*e*(U_n+U_h);//Conductivity of pure
     silicon crystal
10 p_i=1/(Sigma_i);//Resistivity of silicon crystal in
     Ohm-cm
11 P_i=p_i*10^(-2);//Resistivity of silicon crystal in
     Ohm-m
12 disp(Sigma_i,'Conductivity of pure silicon crystal(
     in mho/cm)=');
13 disp(P_i,'Resistivity of silicon crystal (in Ohm-m)=
     ');
```

Scilab code Exa 15.2 Find the resistivity at room temperature

```
1 //Exam:15.2
2 clc;
3 clear;
4 close;
5 U=1200;//electron mobility in cm2/Volt-sec
6 e=1.6*10^(-19);//charge on the electron in C
7 n=10^13;//concentration of phosphorus
8 sigma=U*e*n;//conductivity of crystal in mho/cm
9 p_i=1/sigma;//resistivity of silicon wafer if all
    donor atom are active
10 disp(p_i,'resistivity of silicon wafer if all donor
    atom are active(in ohm-cm)=');
```

Scilab code Exa 15.3 Find the resistance of an intrinsic germanium rod

```
1 //Exam:15.3
2 clc;
3 clear;
4 close;
5 U_n=3900//mobility of electron in cm2/volt-sec
6 U_h=1900//hole mobility in cm2/volt-sec
7 n_i=2.5*10^13;//concentration of electron
8 u_n=U_n*10^(-4);//mobility of electron in m2/volt-
    sec
9 u_h=U_h*10^(-4);//hole mobility in m2/volt-sec
10 e=1.6*10^(-19);//charge on the electron in C
11 Sigma_i=n_i*e*(u_n+u_h)*10^6;//Conductivity
12 p_i=1/(Sigma_i);//resistivity of intrinsic germanium
     rod
13 l=1*10^(-2);//length of germanium rod in m
```

```
14 w=1*10^(-3);//width of germanium rod in m
15 t=1*10^(-3);//thick of germanium rod in m
16 A=w*t;//Area of cross section in m2
17 R=p_i*l/A;//Resistance of an intrinsic germanium rod
       in Ohm
18 disp(R/10^3,'Resistance of an intrinsic germanium
     rod (in K-Ohm)=');
```

Scilab code Exa 15.4 Obtain density relation in P type material

```
1 //Exam:15.4
2 clc;
3 clear;
4 close;
5 N_a=1.1*10^20;//acceptor density in atoms/m3
6 n_i=2.5*10^19;//concentration of majority carrier
     per m3
7 n_p=(n_i^2)/N_a;//intrinsic density
8 R=n_p/n_i;//Ratio of n_p and n_i
9 disp(R,'n_p/n_i=');
```

Chapter 16

Superconductivity and Superconducting Materials

Scilab code Exa 16.1 Energy gap in electron volts and Calculate the wavelength of a photon

```
1  //Exam:16.1
2  clc;
3  clear;
4  close;
5  T_c=4.2;//critical temperature of mercury
6  k=1.4*10^(-23);//
7  E_g=3*k*T_c;//energy gap (in Joule)
8  e=1.6*10^(-19);//charge on the electron
9  E=E_g/e;//energy gap (in electron volt)
10 h=6.6*10^(-34)// in J-s
11 c=3*10^8;//in m/s
12 wavelength=h*c/E_g;//wavelength of a photon (in m)
13 disp(E,'energy gap (in electron volt)=');
14 disp(wavelength,'wavelength of a photon (in m)=');
```

Chapter 18

Composites

Scilab code Exa 18.1 Calculate the modulus of elasticity

```
1 //Exam:18.1
2 clc;
3 clear;
4 close;
5 E_f=69;//modulus of elasticity in GPa
6 V_f=40/100;//Volume of glass fibres %
7 E_m=3.4;//modulus (in GPa)
8 V_m=60/100;//Volume of polyester resin %
9 E_cl=E_m*V_m+E_f*V_f;//modulus of elasticity (in Gpa
    )
10 disp(ceil(E_cl),'modulus of elasticity(in Gpa)=');
```

Scilab code Exa 18.2 Elastic modulus when the stress is applied perpendicular to the direction of the fibre alignment

```
1 //Exam:18.2
2 clc;
3 clear;
```

```
close;
E_f=69;//modulus of elasticity in GPa
V_f=40/100;//Volume of glass fibres %
E_m=3.4;//modulus (in GPa)
V_m=60/100;//Volume of polyester resin %
E_cl=E_m*E_f/(E_m*V_f+E_f*V_m);//modulus of
   elasticity when the stress is applied
   perpendicular to the direction of the fibre
   alignment(in Gpa)
disp(E_cl,'modulus of elasticity when the stress is
   applied perpendicular to the direction of the
   fibre alignment(in Gpa)=');
```