Scilab Textbook Companion for Nuclear Chemistry through Problems by H. J. Arnikar and N. S. Rajurkar[1]

Created by
Suraj Bidwai
B. Tech
Chemical Engineering
Visvesvaraya National Institute of Technology
College Teacher
None
Cross-Checked by
Harpreeth Singh

June 4, 2016

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

Book Description

Title: Nuclear Chemistry through Problems

Author: H. J. Arnikar and N. S. Rajurkar

Publisher: New Age International, New Delhi.

Edition: 1

Year: 1997

ISBN: 81-224-1036-7

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

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

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

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

Contents

List of Scilab Codes

Chapter 1

Nuclear Chemistry through Problems

Scilab code Exa 1.1 P1 1

```
1 //Ex1_1
2
3 clc;
4 //Given:
5 v=1000;// potential
6 d=0.05;// distance
7 q=3.8*10^-9;// charge
8
9 //solution:
10 e=v/d;//electric field
11 f=e;// force
12 f1=f*q;// force on metal sphere
13 printf("\n The electric field in V/m is = %f ",e)
14 printf("\n The force in N/C is = %f ",f)
15 printf("\n The force on metal sphere in N is = %f ",
   f1)
```

Scilab code Exa 1.2 P1 2

```
1 //Ex1_2
2
3 clc;
4 //Given:
5 energy=2*10^-6;
6 c=2.5*10^-8;// velocity of light
7 //solution:
8 v=energy/c;// potential
9 printf("The potential in V is = %f ",v)
```

Scilab code Exa 1.3 P1 3

```
1 //Ex1_3
2
3 clc;
4 //Given:
5
6 energy=10; //in electron volts
7 m=9.1*10^-31;// mass of electron in kg
8 h=6.626*10^-34;// planck's constant J.s
9 c=3*10^8;// speed of light in m/s
10
11 //solution (a):
12 energy1=energy*1.6*10^-19;// energy in J
13 p=(2*m*energy1)^0.5;// momentum
14 wavelength=h/p*(10)^10;
15
16 printf("The wavelength in Angstroms is = %f ",
     wavelength)
17
18
19 //solution (b):
20 wavelength1=h*c/energy1*(10)^10;//photon wavelength
```

```
21
22 printf("\n The photon wavelength in Angstroms is =
      %f ",wavelength1)
```

Scilab code Exa 1.4 P1 4

```
1  //Ex1_4
2
3  clc;
4
5  //Given:
6
7  wavelength=10^-10;
8  m=9.1*10^-31;
9  h=6.626*10^-34;
10
11 //solution:
12
13 p=h/wavelength;
14 e=p*p/(2*m); // energy in J
15 e1=e/(1.6*10^-19);// energy in eV
16
17 printf("The energy in eV is = %f ",e1)
```

Scilab code Exa 1.5 P1 5

```
1  //Ex1_5
2
3  clc;
4
5  //Given:
6
7  m=1.66*10^-27;// 1u=1.66*10^-27 kg
```

```
8  h=6.6262*10^-34;//planck's constant in J.s
9  energy1=120;// in Mev for oxygen
10 energy2=140;// in MeV for nitrogen
11
12 //solution(a):
13
14 p=(2*m*16*energy1*(1.6022*10^-13))^0.5;
15 wavelength1=h/p*(10)^15;//wavelength in 10^-5
      Angstroms
16
17 printf("\n The wavelength in 10^-5 Angstroms is = %f
       ",wavelength1)
18
19 //solution (b):
20
21 p=(2*m*14*energy2*(1.6022*10^-13))^0.5;
22 wavelength2=h/p*(10)^15;//wavelength in 10^-5
      Angstroms
23
24 printf("\n The wavelength in 10^-5 Angstroms is = %f
       ",wavelength2)
25
26 // 1 Angstrom = 10^-10 m
```

Scilab code Exa 1.6 P1 6

```
1 //Ex1_6
2
3 clc;
4
5 //Given:
6
7 wavelength=1.5*10^-10;
8 h=6.62*10^-34;
9 c=3*10^8;
```

```
10
11 //solution:
12
13 e=(h*c)/wavelength;// energy in J
14 e1=e/(1.6*10^-19);// energy in eV
15
16 printf("The energy in eV is = %f ",e1)
```

Scilab code Exa 1.7 P1 7

```
1 //Ex1_7
2
3 clc;
4
5 //Given:
6
7 E=5.12*1.6*10^-19// energy in J
8 h=6.626*10^-34;
9 c=3*10^8;
10 wavelength=200*10^-9;
11 w=2.3;// in eV
12
13 //solution:
14
15 tf=E/h;// (part a)
16 printf("\n The threshold frequency in s^-1 is = %f "
   ,tf)
17
18 tl=c/tf*10^10;// (part b)
19 printf("\n The threshold wavelength in Angstroms is
   = %f ",tl)
20
21 e=(h*c)/(wavelength*1.6*10^-19)// photon energy in
   eV (part c)
22
```

```
23 pe=e-w;
24
25 printf("\n The energy of photoelectrone in eV is =
     %f ",pe)
```

Scilab code Exa 1.8 P1 8

```
1  //Ex1_8
2
3  clc;
4
5  //Given:
6  e1=1; // in MeV
7  e2=2; // in MeV
8  ma=4; // in u(amu)
9  md=2; // in u(amu)
10 mp=1; // in u(amu)
11
12 // 1u = 1.6*10^-27 Kg
13
14 //solution: part a)For alpha particles
15
16 v1a=((2*e1*10^6*1.6*10^-19)/(ma*1.6605*10^-27))^.5;
17 printf("\n The velocity of alpha particles for 1 MeV
       in m/s is = %f ",v1a)// For 1 MeV
18
19 v2a=((2*e2*10^6*1.6*10^-19)/(ma*1.6605*10^-27))^.5;
20 printf("\n The velocity of alpha particles for 2 MeV
       in m/s is = %f ",v2a)// For 2 MeV
21
22 //solution: part b)For deuteron particles
23
24 v1b=((2*e1*10^6*1.6*10^-19)/(md*1.6605*10^-27))^.5;
25 printf("\n The velocity of deuteron particles for 1
     MeV in m/s is = %f ",v1b) // For 1 MeV
```

```
26
27
28 v2b=((2*e2*10^6*1.6*10^-19)/(md*1.6605*10^-27))^.5;
29 printf("\n The velocity of deuteron particles for 2
     MeV in m/s is = %f ",v2b) // For 2 MeV
30
31 //solution: part c)For proton particles
32
33 v1p=((2*e1*10^6*1.6*10^-19)/(mp*1.6605*10^-27))^.5;
34 printf("\n The velocity of proton particles for 1
     MeV in m/s is = %f ",v1p) // For 1 MeV
35
36
37 v2p=((2*e2*10^6*1.6*10^-19)/(mp*1.6605*10^-27))^.5;
38 printf("\n The velocity of proton particles for 2
     MeV in m/s is = %f ",v2p) // For 2 MeV
```

Scilab code Exa 1.9 P1 9

```
1
2 //Ex1_9
3
4 clc;
5
6 //Given:
7
8 m=1/(6.023*10^23);//mass of 1 atom in g
9 m1=m*10^-3;//mass of 1 atom in Kg
10 c=3*10^8;// velocity in m/s
11 //solution:
12
13 e=m1*c*c; // energy in J
14 e1=e/(1.6*10^-13);// energy in MeV
15
16 printf("The energy in MeV is = %f ",e1)
```

Scilab code Exa 1.10 P1 10

```
1
2 //Ex1_10
3
4 clc;
5
6 //Given:
7
8 enthalpy=1278; // enthalpy of combustion in kJ/mol
9
10 //solution:
11
12 energy=(enthalpy*1000)/(6.022*10^23*1.6*10^-19);
13
14 printf("The energy in eV is = %f ",energy)
```

Scilab code Exa 1.11 P1 11

```
1 //Ex1_11
2
3 clc;
4
5 //Given:
6 mh=1.0078;
7 mn=1.0087;
8 ma=4.0026;
9 mo=15.9949;
10 Ah=4.0026; // atomic mass of helium
11 Ao=15.9949; // atomic mass of oxygen
12
```

```
13 //solution:
14
15 // part (a)
16
17 B1=(2*mh+2*mn-ma)*931; // in MeV
18 Bh=B1/Ah;
19 printf("\n The mean binding energy of helium atom in
       MeV is = %f ",Bh)
20
21 // part (b)
22
23 B2=(8*mh+8*mn-mo)*931; // in MeV
24 Bo=B2/Ao;
25 printf("\n The mean binding energy of oxygen atom in
       MeV is = %f ",Bo)
```

Scilab code Exa 1.12 P1 12

```
1
2 //Ex1_12
3
4 clc;
5
6 //Given:
7 mh=1.0078;
8 mn=1.0087;
9 ABe=8.0053; // atomic mass of beryllium
10
11 //solution:
12
13 B1=(4*mh+4*mn-ABe)*931; // in MeV
14 Bh=B1/ABe;
15 printf("\n The mean binding energy of Be atom in MeV
       is = %f ",Bh)
16
```

```
17 disp("From previous problem we have the avg. binding
       energy of helium atom is          7.08 MeV, Hence
     Be is unstable to fission into 2 alphas")
```

Scilab code Exa 1.13 P1 13

```
1
2 //Ex1_13
3
4 clc;
5
6 //Given:
7
8 e=200; // in Mev
9 m=0.235; // weight of uranium atom in Kg
10 enthalpy=393.5; // in KJ/mol
11 Na=6.02*10^23;
12
13
14 //solution:
15 e1=e*1.6*10^-19*10^6;
16 atoms=Na/m;
17 e2=atoms*e1;//energy released in J
18 m1=(e2*12)/(393.5*1000*1000);// in Kg
19 m2=m1/1000;// in tons
20 printf("\n The amount of coal required in Kg is = %f
     ", m2)
```

Scilab code Exa 1.14 P1 14

```
1
2 //Ex1_14
3
```

```
4  clc;
5
6  //Given:
7  H1=241.8; // in KJ/mol
8  H2=887.2; // in KJ/mol
9  // 1 KJ/mol = 0.0104 eV/atom
10
11 //solution: part (a)
12 e1=H1*0.0104;
13 printf("\n The energy release in part (a) in eV/
       molecule is = %f ",e1)
14
15 //solution: part (b)
16 e2=H2*0.0104;
17 printf("\n The energy release in part (b) in eV/
       molecule is = %f ",e2)
```

Scilab code Exa 1.15 P1 15

```
1
2  //Ex1_15
3
4  clc;
5
6  //Given:
7  H1=4.1; // in eV/molecule
8  H2=17.4; // in eV/molecule
9  H3=200;// in MeV/atom of U
10
11 // 1 eV/atom  = 96.32 KJ/mol
12
13 //solution: part (a)
14 e1=H1*96.32;
15 printf("\n The energy release in part (a) in KJ/mol
       of carbondioxide is = %f ",e1)
```

```
16
17 //solution: part (b)
18 e2=H2*96.32;
19 printf("\n The energy release in part (b) in KJ/mol
      of alumina is = %f ",e2)
20
21 //solution: part (c)
22 e3=H3*1000*96.32;// in MJ/atom of U(235)
23 printf("\n The energy release in part (c) in MJ/atom
       of U(235) is = %f ",e3)
```

Scilab code Exa 1.16 P1 16

```
1
2 //Ex1_16
3
4 clc;
5
6 //Given:
7 e=200; //MeV/ atom of U
8 // 1 eV = 1.6*10^-19 J
9 Na=6.023*10^23;
10 M=0.235; // mass in Kg
11
12 //solution:
13
14 e1=e*1.6*10^-19*10^6;
15 A=Na/M;
16 e2=A*e1; // energy released in MJ/day
17 e3=e2/(24*3600);
18 printf("\n The rate of energy release in W is %f ",
      e3)
```

Scilab code Exa 1.17 P1 17

```
1 //Ex1_17
2
3 clc;
4
5 //Given:
6 e=26.03; // in MeV
7
8 //solution:
9
10 loss=e/931; //in atomic mass units (u)
11 // 1 u = 1.66*10^-27 Kg
12 m=(loss*1.66*10^-27)/(1*10^-27);
13 printf("\n The mass loss in 10^-27 Kg/He formed is =
       %f ",m)
```

Scilab code Exa 1.18 P1 18

```
1
2 //Ex1_18
3
4 clc;
5
6 //Given:
7 mh=1.007825;
8 mt=3.016049;
9 md=2.014102;
10
11 //solution:
12
13 m1=(mh+mt-2*md);
14 e=(-m1)*931; // in MeV
15 printf("\n The energy loss in MeV is = %f ",e)
```

Scilab code Exa 1.19 P1 19

```
1
2 //Ex1_19
3
4 clc;
5
6 //Given:
7 mh=1.007825;
8 mn=1.008665;
9 mt=3.016049; // atomic mass of Tritium
10 mNi=59.93528; // atomic mass of Nickel
11
12 //solution:
13
14 // part (a)
15
16 B1=(1*mh+2*mn-mt)*931; // in MeV
17 Bh=B1/mt;
18 printf("\n The mean binding energy of tritium atom
    in MeV is = %f ",Bh)
19
20 // part (b)
21
22 B2=(28*mh+32*mn-mNi)*931; // in MeV
23 Bo=B2/mNi;
24 printf("\n The mean binding energy of nickel atom in
    MeV is = %f ",Bo)
```

Scilab code Exa 1.20 P1 20

```
1
```

```
2
3 //Ex1_20
4
5 clc;
6
7 //Given:
8 mh=1.00783;
9 mn=1.00867;
10 m35=34.96885; // atomic mass of Cl (35)
11 m37=36.96590; // atomic mass of Cl (37)
12
13 //solution:
14
15 B1=(17*mh+18*mn-m35)*931; // in MeV
16 Bh=B1/m35;
17 printf("\n The mean binding energy of Cl (35) atom
      in MeV is = %f ",Bh)
18
19 B2=(17*mh+20*mn-m37)*931; // in MeV
20 Bo=B2/m37;
21 printf("\n The mean binding energy of Cl (37) atom
      in MeV is = %f ",Bo)
22
23 Bi=Bo-Bh;
24 printf("\n The increase in mean binding energy of Cl
       atom in MeV is = %f ",Bi)
25
26 // NOTE: The answer depends upon how much precise
      value you take for atomic masses.
```

Scilab code Exa 1.21 P1 21

```
1
2 //EX1_21
3
```

```
4  clc;
5
6  //Given:
7  mh=1.0078;
8  mn=1.0087;
9  m22=21.99431;// atomic mass of Na 22
10 m23=22.9898;// atomic mass of Na 23
11 m24=23.9909;// atomic mass of Na 24
12
13 //solution:
14
15 // part (a)
16
17 B1=((11*mh+11*mn)-m22)*931; // in MeV
18 Bh=B1/m22;
19 printf("\n The mean binding energy of Na(22) in MeV
      is = %f ",Bh)
20
21 // part (b)
22
23 B2=((11*mh+12*mn)-m23)*931; // in MeV
24 Bo=B2/m23;
25 printf("\n The mean binding energy of Na(23)in MeV
      is = %f ",Bo)
26
27 // part (c)
28
29 B3=((11*mh+13*mn)-m24)*931; // in MeV
30 Bs=B3/m24;
31 printf("\n The mean binding energy of Na(24) in MeV
      is = %f ",Bs)
```

Chapter 2

Nuclear Chemistry through Problems

Scilab code Exa 2.1 P2 1

```
1
2 //Ex2_1
3
4 clc;
5
6 //Given:
7 f=19;// atomic mass no. of F
8 a=197;// atomic mass no.of Au
9 p=239;// atomic mass no. of Pu
10 //solution:(a)
11
12 m1=f/(6.02*10^23);
13 Rf=1.4*(f^(1/3))*10^-13;// in cm
14 V1=1.3333*3.14*(Rf)^3;
15 df=m1/(V1*10^14);// density in 10^14 g cm^-3
16 printf("\n The density nucleus of F(19) in 10^14 g
   cm^-3 is = %f ",df)
17
18 //(b)
```

```
19 m2=a/(6.02*10^23);
20 Ra=1.4*(a^(1/3))*10^-13;// in cm
21 V2=1.3333*3.14*(Ra)^3;
22 da=m2/(V2*10^14);// density in 10^14 g cm^-3
23 printf("\n The density nucleus of Au(197) in 10^14 g
       cm^-3 is = %f ",da)
24
25
26 //(c)
27 m3=p/(6.02*10^23);
28 Rp=1.4*(p^(1/3))*10^-13;// in cm
29 V3=1.3333*3.14*(Rp)^3;
30 dp=m3/(V3*10^14);// density in 10^14 g cm^-3
31 printf("\n The density nucleus of P(239) in 10^14 g
      cm^-3 is = %f ",dp)
32
33 // Note: The density for Au(197) is not calculated
      correctly in the textbook.
```

Scilab code Exa 2.2 P2 2

```
1
2 //Ex2_2
3
4 clc;
5
6 // Given:
7 // (a) Be(8)= 2 He(4)
8 // (b) Kr(80)= 2 Ar(40)
9 // (c) Cd(108)= 2 Cr(54)
10
11
12 // Solution:
13 m1=8.0053-2*4.00260;
14 m2=79.81638-2*39.96238;
```

```
15 m3=107.90418-2*53.93888;
16
17
18 if m1>0 then
19     printf("\n Case (a) Fission is possible since m1
         = %f",m1)
20 else
21     printf("\n Case (a) Fission is not possiblesince
          m1= %f",m1)
22 end
23
24 if m2>0 then
25   printf("\n Case (b) Fission is possible since m2=
       %f",m2)
26  else
27     printf("\n Case (b) Fission is not possible
         since m2= %f",m2)
28 end
29
30 if m3>0 then
31     printf("\n Case (c) Fission is possible since m3
         = %f",m3)
32 else
33     printf("\n Case (c) Fission is not possible
         since m3= %f",m3)
34 end
```

Scilab code Exa 2.3 P2 3

```
1
2 // Ex2_3
3
4 clc;
5
6 // Given:
```

```
l=3;
f=3;
s=1/2;

// Solution:
I=l-s;// total angulr momentum
P=(-1)^(l);//nuclear parity
mm=(I-2.293*(I/(I+1)));// in nuclear magneton

printf("\n Nuclear spin of the nucleus is %f",I)
if P>0 then
    printf(" (+) ")
else
    printf(" (-) ")
end

printf("\n Magnetic moment is = %f in nuclear
   magneton",mm)
```

Scilab code Exa 2.4 P2 4

```
1
2 // Ex2_4
3
4 clc;
5
6 // Given:
7
8 l=4;
9 g=4;
10 s=1/2;
11
12 // Solution:
13 I=l+s;// total angulr momentum
14 P=(-1)^(l);//nuclear parity
```

```
15 mm=(I+2.293);// for odd proton and I=l+s in nuclear
      magneton
16
17 printf("\n Nuclear spin of the nucleus is %f",I)
18 if P>0 then
19     printf(" (+) ")
20 else
21     printf(" (-) ")
22 end
23 printf("\n Magnetic moment is = %f in nuclear
      magneton",mm)
```

Scilab code Exa 2.5 P2 5

```
1
2 // Ex2_5
3
4 clc;
5
6 // Given:(a) Cs(55) (b) Kr(36)
7
8 // Solution: Part(a)
9 disp(" The odd nucleon is 55 proton in level 2 d 5/2
      (+). Hence spin is 5/2 and parity (+)")
10 mm=((5/2)+2.293);
11 printf("\n Magnetic moment is = %f in nuclear
      magneton",mm)
12 // Solution: Part(b)
13 printf("\n \n The odd nucleon is 47 neutron in level
      1 g 9/2 (+). Hence spin is 9/2 and parity (+)")
14 disp("Magnetic moment for neutron is m=-1.913 in
      nuclear magneton")
```

Scilab code Exa 2.7 P2 7

```
1
2 // Ex2_7
3
4 clc;
5
6 // Given:
7 h=6.6262*10^-34;// in J.s
8 f=17.24*10^6;// in Hz/T
9 m=5.05*10^-27;// in J/T
10 // Solution:
11
12 E=h*f;
13 g=E/(m)
14 printf("The nuclear g factor for P is = %f",g)
```

Scilab code Exa 2.8 P2 8

```
1
2 // Ex2_8
3
4 clc;
5 // Given:
6
7 h=6.6262*10^-34;// in J.s
8 f=17.24*10^6;// in Hz/T
9 m=5.05*10^-27;// in J/T
10 g=1.405;
11
12 // Solution:
13
14 E=g*m;
15 f=E/(h*10^6);// NMR frequency
16
```

```
17 printf("The NMR frequency is = %f MHz",f)
```

Scilab code Exa 2.9 P2 9

```
1
2 // Ex2_9
3 clc;
4
5 // Given:
6
7 h=6.6262*10^-34;// in J.s
8 f=30.256*10^6;// in Hz/T
9 m=5.05*10^-27;// in J/T
10 g1=5.585;
11 g2=1.405;
12
13 // Solution:
14 H1=(h*f)/(g1*m);
15 H2=(h*f)/(g2*m);
16 printf("\n Magnetic field required for a proton is =
     %f T",H1)
17 printf("\n Magnetic field required for C 13 is = %f
   T",H2)
```

Scilab code Exa 2.10 P2 10

```
1
2 // Ex2_10
3 clc;
4 // Given:
5
6 h=6.6262*10^-34;// in J.s
7 f=9.302*10^9;// in Hz/T
```

```
8  m=9.274*10^-24;// in J/T
9  g1=2.0025;
10
11
12 // Solution:
13
14 H1=(h*f)/(g1*m);
15 printf("\n Magnetic field required for a proton is =
       %f T",H1)
```

Scilab code Exa 2.11 P2 11

```
1
2  // Ex2_11
3  clc;
4
5  // Given:
6  mf=1.201;// In T
7  h=6.6262*10^-34;// in J.s
8  m=9.2741*10^-24;// in J/T
9  g=2.0025;
10 // Solution:
11 v=(g*m*mf)/(h*10^9);
12 printf("The frequency needed to bring in resonance
       is  = %f GHz",v)
```

Scilab code Exa 2.12 P2 12

```
1
2  // Ex2_12
3  clc;
4
5  // Given:
```

```
mf=1.5;// In T
h=6.6262*10^-34;// in J.s
mb=9.2741*10^-24;// in J/T
mn=5.0504*10^-27;//in J/T
ge=2.002;
gp=5.5854;
// Solution: Part(a)
v1=(gp*mn*mf)/(h*10^6);
printf("\n The frequency needed to bring proton spin
    resonance is  = %f MHz",v1)
// Solution: Part(b)
v2=(ge*mb*mf)/(h*10^9);
printf("\n The frequency needed to bring electron
   spin resonance is  = %f GHz",v2)
```

Scilab code Exa 2.13 P2 13

```
// Ex2_13
clc;

// Given:
h=6.6262*10^-34;// in J.s
f=40.2*10^6;// in Hz/T
m=5.05*10^-27;// in J/T
g1=5.256;


// Solution:
H1=(h*f)/(g1*m);
printf("\n Magnetic field required for causing
   resonance is = %f T",H1)
```

Scilab code Exa 2.14 P2 14

```
1  //Ex2_14
2  clc;
3
4  //Given:
5  mf=1.0;// In T
6  h=6.6262*10^-34;// in J.s
7  mn=5.0504*10^-27;//in J/T
8  gB=5.4;
9  gN=4.01;
10 // Solution:
11 v1=(gB*mn*mf)/(h*10^6);
12
13 v2=(gN*mn*mf)/(h*10^6);
14
15 printf("\n The ratio of NMR frequencies of B/N is =
     %f",v1/v2)
```

Scilab code Exa 2.15 P2 15

```
1
2  // Ex2_15
3  clc;
4
5  // Given:
6  E=14.4*10^-3;// in MeV
7  m=57;
8  // Solution:
9  Er=(536*(E)^2)/(m*10^-3);
10 printf("The recoil energy is = %f meV",Er)
```

Scilab code Exa 2.16 P2 16

```
1
```

```
2 // Ex2_16
3 clc;
4
5 // Given:
6 Er=2.551;// in meV
7 m=119;// atomic wt of Sn
8
9 // Solution:
10 E=sqrt(2.551*10^-3*119/536);// energy emitted by
    nucleus
11 printf("The energy emtted by the nucleus is = %f MeV
    ",E)
```

Scilab code Exa 2.17 P2 17

```
1
2 // Ex2_17
3 clc;
4 // Given:
5 l=10^-10;// in m
6 m=100;// in u
7 h=6.6262*10^-34;// in J.s
8
9
10 // Solution:
11 v=h/(m*l*1.67*10^-27);// velocity
12 f=v/l;// frequency
13
14 printf("The doppler shift frequency is = %f Hz",f)
```

Scilab code Exa 2.18 P2 18

```
1
```

```
2 // Ex2_18
3 clc;
4 //Given:
5 // 1 ev=8065 cm^-1
6 E=14.4*10^3;// in eV
7 // Solution:
8 f1=E*8065;// frequency in cm^-1
9 printf("\n The frequency in cm^-1 is = %f",f1)
10 fr=f1*3*10^8*100;
11 printf("\n The frequency in Hz is = %f",fr)
```

Scilab code Exa 2.19 P2 19

```
1
2 // Ex2_19
3 clc;
4
5 // Given:
6 //Given:
7 // 1 ev=8065 cm^-1
8 E=14.4*10^3;// in eV
9 v1=2.2*10^-3;// in m/s
10 // Solution:
11 f1=E*8065;// frequency in cm^-1
12 fr=f1*3*10^8*100;
13 fr1=(fr*v1)/(3*10^8);
14
15 printf("The shift in frequency between the source
   and the sample is = %f Hz",fr1)
```

Scilab code Exa 2.20 P2 20

```
1
```

```
2 // Ex2_20
3 clc;
4
5 // Given:
6 E=1.6*14.4*10^3*10^-19;// energy in J
7 c=3*10^8;// in m/s
8 m=57*1.6*10^-27;
9 M=10^-4;
10 h=6.6262*10^-34;// in J.s
11 // Solution:
12 p=E/c;
13 v=p/m;
14 v1=(v*m)/(M);
15 v2=(v*m)/(M*10^-20);
16 f1=(E*v)/(h*c);
17 f2=(E*v1)/(h*c*10^-10);
18 printf("\n The recoil velocity of free atom is = %f
   m/s",v)
19 printf("\n The recoil velocity of atom that is part
   of crystal in 10^-20 = %f m/s",v2)
20 printf("\n The doppler shift for free atom is = %f
   Hz",f1)
21 printf("\n The doppler shift of atom that is part of
    crystal in 10^-10 Hz is = %f",f2)
```

Scilab code Exa 2.21 P2 21

```
1
2 // Ex2_21
3 clc;
4
5 // Given:
6 A=175;
7 R=1.4*10^-15*((A)^(1/3));
8 // Soluiton:
```

```
9  //Part a
10 sqrBMinusSqrA = (5.9 * (10^ (-28))) * 5 /(2 * 71);
11
12 BMinusA = sqrBMinusSqrA / (2 * R);
13
14 ellipticity = 2 * (BMinusA) / (2 * R);
15
16 printf("\n Ellipticity is = %f\n",ellipticity);
17
18 //Part B
19
20 b = (BMinusA + (2 * R)) /2;
21 a = (-BMinusA + (2 * R)) /2;
22
23 printf("\n b/a is = %f",b/a);
```

Scilab code Exa 2.22 P2 22

```
1
2  // Ex2_22
3  clc;
4
5  // Given:
6  A1=176;
7  A2=233;
8  R1=1.4*10^-15*((A1)^(1/3));
9  R2=1.4*10^-15*((A2)^(1/3));
10 // Soluiton:
11 //Part a
12
13 sqrBMinusSqrA = (5 * 7 * (10^ (-28))) /(2 * 71);
14
15 BMinusA = sqrBMinusSqrA / (2 * R1);
16
17 ellipticity = 2 * (BMinusA) / (2 * R1);
```

```
18
19 printf("Ellipticity is = %f\n",ellipticity);
20
21 b = (BMinusA + (2 * R1)) /2;
22 a = (-BMinusA + (2 * R1)) /2;
23
24 printf("b/a is = %f\n",b/a);
25
26 //Part B
27
28
29 sqrBMinusSqrA = -(5 * 3 * (10^ (-28))) /(2 * 91);
30
31 BMinusA = sqrBMinusSqrA / (2 * R2);
32
33 ellipticity = 2 * (BMinusA) / (2 * R2);
34
35 printf("Ellipticity is = %f\n",ellipticity);
36
37 b = (BMinusA + (2 * R2)) /2;
38 a = (-BMinusA + (2 * R2)) /2;
39
40 printf("b/a is = %f",b/a);
```

Scilab code Exa 2.23 P2 23

```
1
2
3 // Ex2_23
4 clc;
5
6 // Given:
7 e = 0.03;
8 A=75;
9 R=1.4*10^-15*((A)^(1/3));
```

```
10 // Soluiton:
11
12 BPlusA = 2 * R;
13
14 BMinusA = e * R;
15 sqrBMinusSqrA = BPlusA * BMinusA;
16
17 BMinusA = sqrBMinusSqrA / (2 * R);
18
19 Q = (2*33*sqrBMinusSqrA)/5;
20 q1=Q/10^-28;
21 printf("Quadrapole moment is = %f in barns",q1);
```

Chapter 3

Nuclear Chemistry through Problems

Scilab code Exa 3.1 P3 1

```
1  //Ex3_1
2
3  clc;
4
5  //Given in cgs units
6  m1=232;
7  m2=1;
8  m3=4;
9  z1=90;
10 z2=1;
11 z3=2;
12 e=4.8*10^-10;// in ergs
13 c=1.4;// nuclear radius constant
14
15 //Formula: E=(z1*z2*e^2)/(r1+r2)
16 r1=(m1)^(1/3);
17 r2=(m2)^(1/3);
18 r3=(m3)^(1/3);
19 E1=(z1*z2*e*e)/(c*(r1+r2)*10^-13*(1.6*10^-6));
```

```
20 printf("\n The coulomb barrier for the penetration
      of Th by proton is = %f MeV",E1)
21 E2=(z1*z3*e*e)/(c*(r1+r3)*10^-13*(1.6*10^-6));
22 printf("\n \n The coulomb barrier for the
      penetration of Th by alpha particle is = %f MeV",
      E2)
```

Scilab code Exa 3.2 P3 2

```
1 //Ex3_2
2
3 clc;
4
5 //Given in cgs units
6 m1=112;
7 m2=1;
8 m3=4;
9 m4=66;
10 z1=50;
11 z2=1;
12 z3=2;
13 z4=30;
14 e=4.8*10^-10;// in ergs
15 c=1.4;// nuclear radius constant
16
17 //Formula: E=(z1*z2*e^2)/(r1+r2)
18 r1=(m1)^(1/3);
19 r2=(m2)^(1/3);
20 r3=(m3)^(1/3);
21 r4=(m4)^(1/3);
22 E1=(z1*z2*e*e)/(c*(r1+r2)*10^-13*(1.6*10^-6));
23 printf("\n The coulomb barrier for the penetration
      of Th by proton is = %f MeV",E1)
24 E2=(z4*z3*e*e)/(c*(r4+r3)*10^-13*(1.6*10^-6));
25 printf("\n \n The coulomb barrier for the
```

```
penetration of Th by alpha particle is = %f MeV",
E2)
```

Scilab code Exa 3.3 P3 3

```
1
2 // Ex3_3
3 clc;
4 // Given:
5 E=6;// in MeV
6 z1=79;
7 z2=2;
8 q=4.8*10^-10;
9 // Solution:
10
11 // At the closest distance of approach, the kineic
   energy of the alpha particle balances the columb
   barrier energy.
12
13 r1=(z1*z2*q*q)/(E*1.6*10^-6);// distance in cm
14 r=r1*10^13;// distance in fm
15
16 printf("The closest distance of approach is = %f fm"
   ,r)
```

Scilab code Exa 3.4 P3 4

```
1
2 // Ex3_4
3 clc;
4 // Given:
5 A=180;
6
```

```
// Solution:
z=(40*A)/(0.6*(A^(2/3))+80);
printf("The stable nuclied of the isobaric series is
    Hf atomic no. = %d",z)
```

Scilab code Exa 3.5 P3 5

```
1
2 // Ex3_5
3 clc;
4
5 // Given:
6 A=87;
7
8 // Solution:
9 z=(40*A)/(0.6*(A^(2/3))+80);
10 printf("The stable nuclied of the isobaric series is
    Sr atomic no. = %f",z)
11 // nereast integer is 38
12
13 printf("\n Hence the nuclides of z<38 fall on the
   left of the limb of B vs Z parabola while the
   nuclides of z>38 fall on the right limb of the
   parabola.")
```

Scilab code Exa 3.7 P3 7

```
1
2 // Ex3_7
3
4 clc;
5
6 // Given:
```

```
B=11.009305;
C1=12;
C2=11.001433;
p=1.0078;
n=1.0087;
Al=26.981535;
Si1=27.976927;
Si2=26.986705;
// Solution:
m1=(B+p-C1);//(a)
E1=m1*931;// of last proton in C in MeV
printf("\n The binding energy for the last proton in
    12C is = %f MeV",E1)

m2=(C2+n-C1);//(b)
E2=m2*931;// of last neutron in C in MeV
printf("\n The binding energy for the last neutron
   in 12C is = %f MeV",E2)

m3=(Al+p-Si1);//(c)
E3=m3*931;// of last proton in Si in MeV
printf("\n The binding energy for the last proton in
    28Si is = %f MeV",E3)

m4=(Si2+n-Si1);//(d)
E4=m4*931;// of last neutron in Si in MeV
printf("\n The binding energy for the last neutron
   in 28Si is = %f MeV",E4)

// Note: There is a calculation error in the
   textbook for the (b) part.
```

Scilab code Exa 3.8 P3 8

```
// Ex3_8
```

```
2
3 clc;
4
5 // Given:
6 d=2.014102;
7 C=12;
8 a=4.002603;
9 N=14.003074;
10 O=15.994915;
11
12 // Solution:
13 m1=(C+d-N);
14 E1=m1*931;// The binding energy for N(14)
15 printf("\n The binding energy for N(14) is = %f MeV"
     ,E1)
16
17 m2=(C+a-O);
18 E2=m2*931;//The binding energy for O(16)
19 printf("\n The binding energy for O(16) is = %f MeV"
     ,E2)
```

Scilab code Exa 3.9 P3 9

```
1 // Ex3_9
2 clc;
3
4
5 // Given:
6 D=-1.997042;
7 n=1.0087;
8 // Solution:
9 m=(D+2*n);
10 E=m*931;
11 printf("\n The binding energy is = %f MeV",E)
```

Scilab code Exa 3.10 P3 10

```
// Ex3_10

clc;

// Given:
mH=1.007825;
mn=1.008665;
M1=207.97666;// mass of Pb 208
M2=206.97590;// mass of Pb 207
M3=206.97739;// mass of Tl 207

// Solution:

B1=((82*1.007825+126*1.008665)-207.97666)*931;//
   binding energy for Pb 208
B2=((82*1.007825+125*1.008665)-206.97590)*931;//
   binding energy for Pb 207
B3=((81*1.007825+126*1.008665)-206.97739)*931;//
   binding energy for Tl 207
Sn=B1-B2;// neutron seperation energy
Sp=B1-B3;// proton seperation energy

printf("\n The neutron seperation energy is = %f MeV
   ",Sn)
printf("\n The proton seperation energy is = %f MeV"
   ,Sp)
```

Scilab code Exa 3.11 P3 11

```

```

```
2 // Ex3_11
3
4 clc;
5
6 // Given:
7 mH=1.007825;
8 mn=1.008665;
9 M1=22.98977;// mass of Na 23
10 M2=21.994435;// mass of Na 22
11 M3=21.991385;// mass of Ne 22
12 // Solution:
13
14 m1=((11*1.007825+12*1.008665)-M1);
15 m2=((11*1.007825+11*1.008665)-M2);
16 m3=((10*1.007825+12*1.008665)-M3);
17 Sn=(m1-m2)*931;// neutron seperation energy
18 Sp=(m1-m3)*931;// proton seperation energy
19
20 printf("\n The neutron seperation energy is = %f MeV
   ",Sn)
21 printf("\n The proton seperation energy is = %f MeV"
   ,Sp)
22
23 // Note: The answers are given in the form of atomic
    mass units where as in the question its asked
   for energies.
```

Scilab code Exa 3.12 P3 12

```
1
2 // Ex3_12
3
4 clc;
5
6 // Given:
```

```
C=0.3;// in MeV^-1
a=2.0;// in MeV
E=8; // in MeV

// Solution:
d=C*(exp(2*((2*8)^(0.5))));// excited level density
s=(1/d)*1000;// level spacing
nT=(E/a)^(0.5);// nuclear temperature
printf("\n The excited level density is = %f MeV",d)
printf("\n The level spacing is = %f keV",s)
printf("\n The nuclear temperature is = %f MeV",nT)
```

Scilab code Exa 3.13 P3 13

```

// Ex3_13
clc;

// Given:
I0=3/2;// ground state of spin

// Solution:
I1=I0+1;
I2=I0+2;
I3=I0+3;
K=1;// Assumed as some constant
// Formula: E=(h^2/(2*I))*((I*(I+1))-I0*(I0+1))
// Consider   K=(h^2/(2*I))=1

E1=K*((I1*(I1+1))-(I0*(I0+1)));// For 1 excited
   state

E2=K*((I2*(I2+1))-(I0*(I0+1)));// For 2 excited
   state

```

```
20 E3=K*((I3*(I3+1))-(I0*(I0+1)));// For 3 excited
      state
21
22 printf("The expression for 1st, 2nd, and 3rd excited
      states are K times %f, %f & %f respectively.",E1
   ,E2,E3)
```

Scilab code Exa 3.14 P3 14

```
1
2 // Ex3_14
3 clc;
4 // Given:
5 E2=44;// in keV
6
7 // Solution:
8 E4=E2*((4*5)/(2*3));// for part (a)
9 E6=E2*((6*7)/(2*3));// for part (b)
10 E8=E2*((8*9)/(2*3));// for part (c)
11 E10=E2*((10*11)/(2*3));// for part (d)
12
13 printf("\n The energy of state 4 (+) is = %f keV",E4
   )
14 printf("\n The energy of state 6 (+) is = %f keV",E6
   )
15 printf("\n The energy of state 8 (+) is = %f keV",E8
   )
16 printf("\n The energy of state 10 (+) is = %f keV",
   E10)
```

Scilab code Exa 3.15 P3 15

```
1
```

```
2 // Ex3_15
3 clc;
4
5 // Given:
6 E2=44;// in keV
7 En=525;// in keV
8
9 // Solution:
10 n=(En)/E2;
11 //
12 printf("%f",n)
13 printf("\n For the required level of energy 525 keV
     nearest even integer is = %d & spin is (+)",n+1)
```

Scilab code Exa 3.16 P3 16

```
1 //Ex3_16
2 clc;
3 // Given:
4 E2=44;// in keV
5 En1=146;// in keV
6 En2=304;// in keV
7 En3=514;// in keV
8 // Solution:
9 n1=(En1)/E2;
10 n2=(En2)/E2;
11 n3=(En3)/E2;
12 printf("%f",n1)
13 printf("\n For the required level of energy 146 keV
     nearest even integer is = %d & spin is (+)",n1+1)
14 printf("\n \n %f",n2)
15 printf("\n For the required level of energy 304 keV
     nearest even integer is = %d & spin is (+)",n2)
16 printf("\n \n %f",n3)
17 printf("\n For the required level of energy 514 keV
```

```
    nearest even integer is = %d & spin is (+)",n3+1)
18
19 //Note: In the last part (c) the answer given in the
       textbook is 8(+). But the correct answer is
       12(+)
```

Chapter 4

Nuclear Chemistry through Problems

Scilab code Exa 4.1 P4 1

```
1
2 // Ex4_1
3
4 clc;
5
6 //Given:
7 t1=1600;// in year
8 a=11.6*10^17;// atoms
9 // Solution:
10 k=0.693/t1;// year^-1
11 L=(a*226)/k;// atomic mass of Radon is 226
12 printf("The value of avagadro constant is = %f atoms
       per mole",L)
```

Scilab code Exa 4.2 P4 2

```
1
2 // Ex4_2
3 clc;
4
5 // Given:
6 t1=1.3*10^9;// in years
7 w=0.0119;// wt %
8
9 // Solution:
10 N=(w*6.022*10^23)/(40*100);
11 k=(0.693*60)/(t1*3.16*10^7);
12 sa=N*k;// specific activity
13 printf("The specific activity is = %f dis min^-1 g
   ^-1",sa)
```

Scilab code Exa 4.3 P4 3

```
1
2 // Ex4_3
3
4 clc;
5
6 // Given:
7 L=6.022*10^23;
8 // Solution:
9 // 1 mCi= 3.7*10^7 dis/s
10 k1=0.693/(15*3600);
11 N1=3.7*10^7/k1;
12 m1=(24*N1*10^10)/L;
13 printf("\n The no. of atoms of Na(24) are = %f",N1)
14 printf("\n The mass of Na(24) is %f * 10^-10 g",m1)
15 k2=0.693/(14.3*24*3600);
16 N2=3.7*10^7/k2;
17 m2=(32*N2*10^9)/L;
18 printf("\n \n The no. of atoms of P(32) are = %f",N2
```

```
    )
19 printf("\n The mass of P(32) is %f * 10^-9 g",m2)
20 k3=0.693/(1600*3.16*10^7);
21 N3=3.7*10^7/k3;
22 m3=(226*N3*10^3)/L;
23 printf("\n \n The no. of atoms of Ra(226) are = %f",
    N3)
24 printf("\n The mass of Ra(226) is %f * 10^-3 g",m3)
```

Scilab code Exa 4.4 P4 4

```
1
2 //Ex4_4
3
4 clc;
5
6 // Given:
7 t1=12.3;// in yrs
8 L=6.022*10^23;
9 // Solution:
10 k=.693/(t1*3.16*10^7);// in s^-1
11 A=(2*L)/(2.24*10^4);// no. of atoms
12 a1=A*k;// dis per s
13 a=a1/(3.7*10^10);// activity in Ci/cm^3
14 printf("The activity in Ci/cm^3 = %f",a)
```

Scilab code Exa 4.5 P4 5

```
1
2 // Ex4_5
3
4 clc;
5
```

```
6 // Given:
7 t=5736;// in years
8 Nk=16.1;// dis/min
9 L=6.022*10^23;
10 // Solution:
11 k=(0.693*60)/(t*3.16*10^7);
12 N1=Nk/k;// atoms per g for C14
13 N2=L/12;//
14
15 r=(N1*10^12)/N2;// ratio of C14/C12 in atmosphere
16
17 printf("The ratio of C14/C12 in atmosphere in 10^-12
     is = %f",r)
```

Scilab code Exa 4.7 P4 7

```
1
2 //Ex4_7
3 clc;
4
5 // Given:
6 dA = 206-238;
7 dA_Beta=0;
8 dA_Alpha = -4;
9
10 dZ_Alpha = -2;
11 dZ_Beta = 1;
12 nBeta=0; //random initialisation
13 dZ = 82 -92;
14 // Solution:
15 nAlpha = (dA- (dA_Beta* nBeta))/dA_Alpha;
16
17 nBeta = (dZ- (dZ_Alpha * nAlpha))/dZ_Beta;
18
19 printf("Number of alpha decays =%f and number of
```

```
beta decays = %f",nAlpha,nBeta);
```

Scilab code Exa 4.8 P4 8

```
// Ex4_8

clc;
// Given:
E1=0.059;
E2=2.5;
E3=1.33;
Ei=0;
Ef=0;

// Solution:
// delta E for 1,2 & 3 photon
dE1=E1-Ei;
dE2=E2-E3;
dE3=E3-Ef;
// delta I for 1,2 & 3 photon
dI1=2-5;
dI2=4-2;
dI3=2-0;
// EL/ML for 1,2 & 3 photon
ELML1=3+1+1
ELML2=2+1+1;
ELML3=2+1+1;
printf("\n For first photon, dE1=%f MeV, dI1=%f,
    since EL/ML1=%f & (L+PI+PF) is odd, M3",dE1,dI1,
    ELML1)
printf("\n For second photon, dE2=%f MeV, dI2=%f,
    since EL/ML2=%f & (L+PI+PF) is even, E2",dE2,dI2
    ,ELML2)
printf("\n For third photon, dE3=%f MeV, d3I=%f,
    since EL/ML3=%f & (L+PI+PF) is even, E2",dE3,dI3,
```

```
ELML3)
```

Scilab code Exa 4.9 P4 9

```
1
2 // Ex4_9
3 clc;
4
5 // Given:
6 E=2.5; // in MeV
7 // Solution:
8 // 1 Mev/atom=96.32GJ/mole
9 E1=E*96.32// GJ/mole
10 E2=0.1*E1;// for 0.1 mole
11 printf("The energy that would be released for 0.1
   mole of Co will be = %f GJ",E2)
```

Scilab code Exa 4.10 P4 10

```
1
2 // Ex4_10
3 clc;
4
5 // Given
6 E=2.5;// in MeV
7 // Solution:
8 k=0.693/(5.27*3.16*10^7);// decay constant
9 A=k*0.1*6.022*10^23;// atoms/s
10 A1=3.6*10^3*A;// atoms /hr
11
12 E1=A1*E*1.6*10^-13*10^-3;//Energy in KJ/hr
13
```

```
14 printf("The total energy dissipate per hour is = %f
     KJ",E1)
```

Scilab code Exa 4.11 P4 11

```
1
2 // Ex4_11
3 clc;
4
5 // Given:
6 Ma=4;//mass of alpha particle
7 Mr=228;// mass of Th
8 Ea=4; //in MeV
9
10
11 // Solution:
12 Er=(Ma/Mr)*Ea;// energy of recoil
13 Et=Ea+Er;// total energy of transition
14
15 dM=Et/931;// net mass loss in u
16
17 printf("The net mass loss is = %f u",dM)
```

Scilab code Exa 4.12 P4 12

```
1
2 // Ex4_12
3 clc;
4
5 // Given:
6 Ma=4;//mass of alpha particle
7 Mr1=222;// mass of
8 Mr2=208;
```

```
Ea1=4.863;
Ea2=6.082;
// Solution:

Er1=(Ma/Mr1)*Ea1;
Et1=Ea1+Er1;
printf("For Ra emitting alpha")
printf("\n\tEnergy of recoil is %f MeV",Er1)
printf("\n\tTotal transition energy is %f MeV",Et1)
Er2=(Ma/Mr2)*Ea2;
Et2=Ea2+Er2;
printf("\nFor Bi emitting alpha")
printf("\n\tEnergy of recoil is %f MeV",Er2)
printf("\n\tTotal transition energy is %f MeV",Et2)
```

Scilab code Exa 4.13 P4 13

```

// Ex4_13
clc;

// Given:
dm=0.006332;// in u
ma=4;
mCm=244;

// Solution:

E=dm*931;// in MeV
KE=E*(ma/mCm); // in MeV
v=sqrt((2*KE*1.6*10^-13)/(240*1.6605*10^-27));
printf("The Kinetic Energy and velocity are %f MeV
   and %f m/s respectively",KE,v)
```

Scilab code Exa 4.14 P4 14

```
1
2 // Ex4_14
3 clc;
4
5 // Given:
6 E0=1.7;// in MeV
7 // Solution:
8 // For E0<2.5 MeV; using Katz and Penfold empirical
    equation we have
9 R1=412*((E0)^(1.265-0.0954*log(E0)));// mg/cm^2
10 // Using feather's relation we have
11 R2=530*E0-106;// mg/cm^2
12
13 printf("The range in Al for beta radiation is %f mg/
    cm^2 using Katz and Penfold empirical equation
    and %f mg/cm^2 using feathers relation.",R1,R2)
```

Scilab code Exa 4.15 P4 15

```
1
2 // Ex4_15
3 clc;
4
5
6 // Solution:
7 L1=(5.5-3.5);// Case 1
8 L2=2-0;// Case 2
9 L3=1.5-.5;// Case 3
10 ELML1=1+0+2;
11 ELML2=1+1+2;
```

```
ELML3=0+1+1;
printf("The order for Case 1 is %f and emission is type (%f) M2,Case 2 is %f and emission is type (%f) E2,Case 3 is %f and emission is type (%f) E1, Case 4 is not possible.",L1,ELML1,L2,ELML2,L3,ELML3)
```

Scilab code Exa 4.16 P4 16

```
// Ex4_16
clc;

// Given:
m=4*10^-3;// in gms
M=210;
E=0.34;// in MeV
// Solution:

N=(m*6.022*10^23)/M;
k=0.693/(5*24*3600);// in s^-1
A=N*k;// in dis/s
// Energy released at 0.34 MeV per dis/s will be
E1=E*A;// in MeV/s
E2=E1*1.6*10^-13;// watts

printf("The rate of energy emission is %f W",E2)
```

Scilab code Exa 4.17 P4 17

```
// Ex4_17
clc;
```

```
// Given:
A=0.2506*10^15;// atoms/s re: Ex4_10
// Solution:
Strength=A/(3.7*10^10);// in kCi
S1=Strength*10^-3;// in KCi
printf("The strength in KCi is %f ",S1)
```

Scilab code Exa 4.18 P4 18

```

// Ex4_18
clc;

// Given:
N1=10^24;// atoms
N2=10^16;// atoms
N3=1000;// atoms
N4=80;// atoms

// Solution:
N11=N1*0.5;// 1st half life
N12=N11/2;// 2nd half life
N13=N12/2;// 3rd half life
printf("\n The 1st half life, 2nd half life, 3rd
   half life are %f, %f, %f respectively.",N11,N12,
   N13)
N21=N2/2;// 1st half life
N22=N21/2;// 2nd half life
N23=N22/2;// 3rd half life
printf("\n The 1st half life, 2nd half life, 3rd
   half life are %f, %f, %f respectively.",N21,N22,
   N23)
N31=N3/2;// 1st half life
N32=N31/2;// 2nd half life
N33=N32/2;// 3rd half life
```

```
23 printf("\n The 1st half life, 2nd half life, 3rd
      half life are %f, %f, %f respectively.",N31,N32,
      N33)
24 //Radiactivity is a statistical property. Decay
      kinetics are reliable only when initial number is
       large
```

Scilab code Exa 4.20 P4 20

```
1
2 // Ex4_20
3 clc;
4
5 // Given:
6 t1=1.28*10^9;// in years
7 // Solution:
8 k=0.693/(1.28*10^9);
9 // beta deay is 88.8%
10 k1=0.888*k;
11 // EC decay is 11.2%
12 k2=0.112*k;
13 tbeta=(0.693*10^-9)/(k1);// partial half life for
      beta decay in Gy
14 tEC=(0.693*10^-9)/(k2);// partial half life for EC
      decay in Gy
15
16 printf("The partial half life for beta decay is %f
      Gy and partial half life for EC decay is %f Gy.",
      tbeta,tEC)
```

Scilab code Exa 4.21 P4 21

```
1
```

```
2 // Ex4_21
3 clc;
4 // Given:
5 t=15.02;// in hours
6 // Solution:
7 ar=1000;// activity ratio given that 0.1% of intial
     activity
8 k=0.693/t;
9
10 t1=(log(ar))/k;
11 printf("The time required will be %f h",t1)
```

Scilab code Exa 4.22 P4 22

```
1
2 // Ex4_22
3 clc;
4 // Given:
5 t=6.01;// in hours
6 // Solution:
7 ar=100/5;// activity ratio given that 5% of intial
     activity
8 k=0.693/t;
9
10 t1=(log(ar))/k;
11 printf("The time required will be %f h",t1)
```

Scilab code Exa 4.23 P4 23

```
1
2 //Ex4_23
3 clc;
4
```

```
5 // Given:
6
7 t=1.83*10^9;// in years
8 // Solution:
9 // Part (a)
10 k=(0.693)/(t*3.16*10^7);
11 k1=(0.693*10^17)/(t*3.16*10^7);// in 10^-17 s^-1
12 printf("\n The overall decay constant will be %f
     *10^-17 s^-1",k1)
13 // Part (b)
14 a=(6.022*10^23)/40; // atoms of K(40)
15 A=a*k;// activity
16 printf("\n The activity for k(40) is %f beta/s",A)
17
18 // Part (c)
19 a1=(6.022*10^23*1.2*10^-4)/41; // atoms of K(41)
20 A1=a1*k;// activity
21 printf("\n The activity for k(41) is %f beta/s",A1)
```

Scilab code Exa 4.24 P4 24

```
1
2 // Ex4_24
3 clc;
4
5 // Given:
6 a1=6520;// c/min
7 a2=4820;//c/min
8 t=2;//min
9 // Solution:
10 k=log(a1/a2)/t;
11 t1=0.693/k;// half life
12 printf("The decay constant is %f min^-1 and the half
     life is %f min",k,t1)
```

Scilab code Exa 4.25 P4 25

```
1
2 // Ex4_25
3 clc;
4 // Given:
5 a=(1/32);// activity drop of its initial value
6 t1=7.5;//in h case(a)
7 t2=64.45;// in min case(b)
8 // Solution:
9 n=log(a)/log(0.5);
10 t11=t1/n;// half life
11 t12=t2/n;// half life
12 printf("The half life for case (a)is %f h and case(b
   ) is %f min",t11,t12)
```

Scilab code Exa 4.26 P4 26

```
1
2 // Ex4_26
3 clc;
4
5 // Given:
6 t238=4.5*10^9;// in y
7 t235=7.04*10^8;// in y
8 a0=0.72;// atoms per cent
9 t=7.04*10^8;
10 // Solution:
11
12 k1=0.693/(t238);//decay constant for U 238
13 N1=(100-a0)*exp(k1*t);
14
```

```
15 k2=0.693/(t235);//decay constant for U 235
16 N2=(a0)*exp(k2*t);
17
18 proportion=N2/N1;
19 printf("The proportion of U235 704 million years
      back is %f" ,proportion)
```

Scilab code Exa 4.27 P4 27

```
1
2 // Ex4_27
3 clc;
4
5 // Given:
6 t=110;// in min
7 a=10;//dpmg^-1
8 // Solution:
9 k=0.693/t;
10 N=a/k;// atoms of F18
11 mass=(N*18)/6.022*10^23;
12 mass1=(N*18*10^20)/(6.022*10^23);// in 10^-20 grams
13 printf("The no. of atoms produced is %f and its mass
      is %f*10^-20 grams",N,mass1)
```

Scilab code Exa 4.28 P4 28

```
1
2 // Ex4_28
3 clc;
4
5 // Given:
6 t=14.3;// half life in days
7 // Solution:
```

```
k=0.693/(t*24*3600);
N=(3.7*10^10)/(k);// No. of atoms in 1 Ci
N1=N*(1-(exp(-0.693/14.3)));// atoms of S32 produced
mass=(N1*32)/(6.022*10^23);

m1=mass*10^6;// in micro grams
printf("The mass in micro-grams is %f.",m1)
```

Scilab code Exa 4.29 P4 29

```
1
2 // Ex4_29
3 clc;
4
5 // Given:
6 t=3.82;// in days
7 // Solution:
8 // part(a)
9 days=1;
10 D1=(1-(exp(-0.693*days/t)))*100;
11 printf("\n The fraction decayed in 1 day will be %f.
   ",D1)
12 // part(b)
13 days=5;
14 D1=(1-(exp(-0.693*days/t)))*100;
15 printf("\n The fraction decayed in 5 days  will be
   %f.",D1)
16 // part(c)
17 days=10;
18 D1=(1-(exp(-0.693*days/t)))*100;
19 printf("\n The fraction decayed in 10 days  will be
   %f.",D1)
20 // part(d)
21 days=6*t;
22 D1=(1-(exp(-0.693*days/t)))*100;
```

```
23 printf("\n The fraction decayed in 6 half lives will
       be %f.",D1)
24 // part(e)
25 n=log(0.001)/log(0.5);
26 printf("\n Time needed for the decay of 99.9 percent
       is %f half lives i.e.%f days.",n,t*n)
```

Scilab code Exa 4.30 P4 30

```
1
2 // Ex4_30
3 clc;
4 // Given:
5 t=2.6;// years
6 // Solution:
7 k=0.693/t;// decay constant
8 //part(a)
9 kbeta=0.89*k;
10 printf("\n The decay constant is %f y^-1",kbeta)
11 kEC=0.11*k;
12 printf("\n The decay constant is %f y^-1",kEC)
13 //part(b)
14 tbeta=0.693/kbeta;
15 printf("\n The half life is %f y",tbeta)
16 tEC=0.693/kEC;
17 printf("\n The half life is %f y",tEC)
```

Scilab code Exa 4.31 P4 31

```
1
2 // Ex4_31
3 clc;
4 // Given:
```

```
5  t=12.8;// hours
6  // Solution:
7  k=0.693/t;// decay constant
8  //part(a)by EC
9  kEC=0.42*k;
10 printf("Decay by EC")
11 printf("\n\t The decay constant is %f h^-1",kEC)
12 tEC=0.693/kEC;
13 printf("\n\t The half life is %f h",tEC)
14
15 //part(b)by beta+
16 kbeta1=0.19*k;
17 printf("\nDecay by beta+")
18 printf("\n\t The decay constant is %f h^-1",kbeta1)
19 tbeta1=0.693/kbeta1;
20 printf("\n\t The half life is %f h",tbeta1)
21
22 //part(b)by beta+
23 kbeta2=0.39*k;
24 printf("\nDecay by beta-")
25 printf("\n\t The decay constant is %f h^-1",kbeta2)
26 tbeta2=0.693/kbeta2;
27 printf("\n\t The half life is %f h",tbeta2)
```

Scilab code Exa 4.32 P4 32

```
1
2  //Ex4_32
3  clc;
4
5  // Given:
6  tU=4.47*10^9;// y
7  tRa=1600;// y
8  tRn=3.82;// days
9  nU=1;
```

```
10 // Solution:
11 //under secular equilibrium we have
12 nRa=(tRa*365/tRn)*nU;
13 nRn=(tU*365/tRn)*nU;
14 printf("The proportion of U,Ra,Rn is 1: %f: %f .",
      nRa,nRn)
```

Scilab code Exa 4.33 P4 33

```
1
2 //Ex4_33
3 clc;
4
5 // Given:
6 ax0 =1; //assume
7 tx = 2; //hrs
8 ty = 1; //hrs
9 // Solution:
10 // general equation connecting Ax and Ay is
11 // Ax(n) = (ky * Ax(0) * (exp(-kx * t) - exp(-ky * t
      ))/ (ky - kx)) + Ay(0) * exp(-ky * t)
12 ax0 = 1;
13 ay4 = (ax0 * (0.693/1) * ((1/4)-(1/16)))/((0.693/1)
      -(0.693/2)) + ax0 * (1/16);
14
15 ax4 = (1* ax0)/4;
16
17 proportion = (ay4 * 100)/(ay4 + ax4);
18
19 printf("The proportion of ay4 at the end of 4 hrs is
      %f",proportion)
```

Scilab code Exa 4.34 P4 34

```
// Ex4_34
clc;

//Given:
Ax0 = 2000; //dps
//Solution:
//part a
ky = 0.693/10;
kx = 0.693/288;
// general equation connecting Ax and Ay is
 Ax12 = (ky * Ax0 * (0.5^(1/24) - 0.5^(1.2)))/ (ky -
     kx);

printf("\n Activity due to La(140) at the end of 12
   hrs will be %f dps",Ax12);
//part b
ky = 0.693/10;
kx = 0.693/288;
// general equation connecting Ax and Ay is
 Ax24 = (ky * Ax0 * (0.5^(2) - 0.5^(57.6)))/ (ky -
    kx);

printf("\n Activity due to La(140) at the end of 24
   d will be %f dps",Ax24);
```

Scilab code Exa 4.35 P4 35

```

// Ex4_35
clc;

// Given:

t1=2.7;// h
t2=3.6;// h
```

```
// Solution:
k1=0.693/t1;
k2=.693/t2;

tmax=(log(k2/k1))/(k2-k1);
printf("The time when daughter activity reaches
   maximum is %f and this is same when activities of
    both are equal.",tmax)
```

Scilab code Exa 4.36 P4 36

```
//Ex4_36
clc;
// Given:
tPo=138;// days
n=24.86;// days
// Solution:
kPo = 0.693/tPo;
// using simplification logx=2(x-1)/(x+1)
kBi=((2 * 2.303)-(n*kPo))/n;
tBi=0.693/kBi;

printf("The half life of Bi is %f days",tBi)
```

Scilab code Exa 4.37 P4 37

```
//Ex4_37
clc;

// Given:
a=10*10^7;// rate
```

```
7  t=15;// h
8  // Soution:
9  A30=a*(1-(0.5)^(2));// dps
10
11 A45=A30*((0.5)^(3));// dps
12
13 printf("The residual activity in the sample is %f
      dps",A45)
```

Chapter 5

Nuclear Chemistry through Problems

Scilab code Exa 5.1 P5 1

```
1
2 // Ex5_1
3 clc;
4
5 // Given:
6 mMg=23.985045;
7 md=2.014102;
8 mAl=25.986900;
9 mNe=19.99244;
10 mNa=21.944;
11 // Solution:
12 // for compound nucleus Al*(26)
13 KE1=(24/26)*8;
14 BE1=(mMg+md-mAl)*931;// in MeV
15 EE1=BE1+KE1;
16 // for compound nucleus Na*(22)
17 KE2=(20/22)*8;
18 BE2=(mNe+md-mNa)*931;// in MeV
19 EE2=BE2+KE2;
```

```
20
21 printf("The excitation energy for Al*(26) is = %f
     MeV and that of Na*(22) is = %f MeV",EE1,EE2)
```

Scilab code Exa 5.2 P5 2

```
1
2 // Ex5_2
3
4 clc;
5
6 // Given:
7 E0=5;// in MeV
8 m=1;
9 M=7
10
11 // Solution:
12
13 Erecoil=(4*5*m*M*((sin(45*3.14/180))^(2)))/((m+M)^2)
     ;
14 Escat=E0-Erecoil;
15
16 printf("\n The energy of protons scattered through
     an angle of 90 deg. is = %f MeV",Escat)
17 Eresi=E0-0.48;
18
19 Erecoil2=(14/64)*Eresi;
20 Escat2=Eresi-Erecoil2;
21 printf("\n \n The energy of proton observed at 90
     deg. after they have excited the lithium to a
     level of 0.48 MeV is = %f MeV",Escat2)
```

Scilab code Exa 5.3 P5 3

```
1
2 // Ex5_3
3
4 clc;
5 // Given:
6 th=2.4;// in Mev
7 z=0.0009;// mp-mn in atomic mass unit
8 // Solution:
9
10 x=-(2.4/931);//assuming no barrier operates
11 y=x+z;
12
13
14 printf("The mass difference between A & B is = %f u"
     , -y)
```

Scilab code Exa 5.4 P5 4

```
1
2 // Ex5_4
3 clc;
4 // Given:
5 mp=1.007277;
6
7 // Solution:
8
9 E1=2*mp*931;// in MeV / part(a)
10
11 E2=E1/2;// in MeV / part (b)
12
13 printf("The energy required for (a) & (b) are = %f &
     %f respectively in MeV",E1,E2)
```

Scilab code Exa 5.5 P5 5

```
// Ex5_5
clc;
//Given
E1=2.059;
E2=2.59;
M1=9;
M2=18;
m=1;

// Solution
Q1=-E1*(M1/(m+M1)); // part(a)
Q2=-E2*(M2/(m+M2)); // part(b)
printf("The Q-values are %f & %f in MeV for B(9) & F
    (19) reactions respectively",Q1,Q2)
```

Scilab code Exa 5.6 P5 6

```

// Ex5_6
clc;
// Given:
Q1=1.136;
Q2=3.236;
M1=11;
M2=13;
m1=2;
m2=1;
// Solution
E1=Q1*((m1+M1)/M1); // part(a)
E2=Q2*((m2+M2)/M2); // part(b)
printf("The thershold energies are %f & %f in MeV
    for B(12) & N(13) reactions respectively",E1,E2)
```

Scilab code Exa 5.7 P5 7

```
1
2 // Ex5_7
3 clc;
4
5 // Given:
6
7 Q1=9.28;// in Mev
8 Q2=0.21;// in Mev
9 Q3=7.25;// in Mev
10 Q4=3.63;// in Mev
11 mn=1.008665;
12 md=1.995311;// mass difference between Fe(56) & Fe
    (54)
13 // Solution:
14 E1=Q1+Q2+Q3+Q4;// part (a)
15 E2=(2*mn-md)*931;// part (b)
16
17 printf("The binding energy of last 2 neutron in part
    (a) and part(b) are = %f & %f in MeV respectively
    ",E1,E2)
```

Scilab code Exa 5.8 P5 8

```
1
2 // Ex5_8
3 clc;
4
5 // Given:
6 Q1=1.2;
7 M1=14;
```

```
m1=4;

// Solution:

E1=Q1*((m1+M1)/M1);
printf("The threshold energy is %f in MeV for O(17)
    reaction",E1)
```

Scilab code Exa 5.9 P5 9

```
//Ex5_9
clc;

// Given:
Q1=3.236;
M1=13;
m1=1;
// Solution:

E1=Q1*((m1+M1)/M1);
printf("The threshold energy is %f in MeV for C(13)
    reaction",E1)
```

Scilab code Exa 5.10 P5 10

```
// Ex5_10
clc;

// Given:
A1=3836;//in barns
E1=1;// in eV
```

```
8  E2=10^6// in eV
9
10 // Solution:
11 vr=sqrt(E2/E1);
12 A2=A1/vr;
13 printf("The cs area required will be = %f b", A2)
```

Scilab code Exa 5.11 P5 11

```
1
2  // Ex5_11
3  clc;
4
5  // Given:
6  a=0.56*10^-24; // area
7  flux=10^13;
8  // Solution:
9  A=6.022*10^23*10^-3*2.5/(58.5);
10 k=A*flux*0.56*10^-24;
11 y=(0.5)^(4/5);
12 activity=k*(1-y);
13 printf("The activity is = %f dis s^-1 g^-1 NaCl",
      activity)
```

Scilab code Exa 5.12 P5 12

```
1
2  // Ex5_12
3  clc;
4
5  // Given:
6  w=0.1189;
7  flux=10^16;
```

```
// Solution:
A=w/(flux*3.16*10^7);// in m^2
A1=A*10000/(10^-24);// in Barns
printf("The cros section area is = %d b", A1)
```

Scilab code Exa 5.13 P5 13

```

// Ex5_13
clc;

// Given:
w=8.52*10^-4;
flux=10^18;
// Solution:

A=w/(flux*24*3600);// in m^2
A1=A*10000/(10^-24);// in Barns
printf("The cros section area is = %f b", A1)
k=flux*A*6.022*10^23/197;
printf("\n \n The saturation activity possible is =
   %f dis s^-1 g^-1", k)
y=(0.5)^(0.3704);
activity=k*(1-y);
printf("\n \n The activity is = %f dis s^-1 g^-1 ",
   activity)
```

Scilab code Exa 5.14 P5 14

```

// Ex5_14
clc;

```

```
// Given:
a=98.7*10^-24; // area in cm ^2
flux=10^16;
d=19.3;// density
l=0.02;// thickness in cm
area=1;// in cm^2
// Solution:
V=area*l;
m=V*d;
A=(6.022*10^23*m)/(197);
k=A*flux*a;
y=exp((-0.693*5)/(2.7*24*60));
activity=k*(1-y);
printf("The activity is = %f dis s^-1 g^-1",activity
    )
// specific activity in Ci/cm^3

a1=activity/(3.7*10^10);// in Ci/gold foil
a2=a1/V;// in Ci/cm^3 of foil

printf("\n The activity in Ci/cm^3 of foil is = %f",
    a2)
```

Scilab code Exa 5.15 P5 15

```

// Ex5_15
clc;

// Given:
r0=1.4*10^-15;// in m
A1=88;
A2=87;
A3=136;
A4=135;
```

```
// Solution:

rSr1=(3.14*(r0*(A1)^(0.33333))^2)/10^-28;// in barns
rSr2=(3.14*(r0*(A2)^(0.33333))^2)/10^-28;// in barns
rXe1=(3.14*(r0*(A3)^(0.33333))^2)/10^-28;// in barns
rXe2=(3.14*(r0*(A4)^(0.33333))^2)/10^-28;// in barns

printf("The geometric cross-section area are %f, %f,
    %f & %f for Sr(88), Sr(87), Xe(136) & Xe(135)
   respectively",rSr1,rSr2,rXe1,rXe2)
```

Scilab code Exa 5.16 P5 16

```

// Ex5_16
clc;

// Given:
m=4*10^-3;// in gms
flux=1.3*10^14;
a=19.6*10^-24;// in cm^2
// Solution:
N=(m/59)*6.022*10^23;
A=N*flux*a*3600;// atoms
k=0.693/(5.25*3.16*10^7);// s^-1

A1=k*A;// Activity in dps

A2=(A1)/(3.7*10^10);// in Ci
A3=(A1*10^3)/(3.7*10^10);// in mCi
A4=A2*37*10^8;// in Bq

printf("\n The activity in mCi is = %f",A3)
printf("\n The activity in Bq is = %f",A4)
```

Scilab code Exa 5.17 P5 17

```
1
2 // Ex5_17
3 clc;
4
5 // Given:
6 a=2.44*1000*10^-24;// in barns
7
8 d=8.64;// g/cm^3
9
10 // Solution:
11 n=(d*6.02*10^23)/112;// atoms/cm^2
12
13 x=(log(100))/(n*a);// in cm
14 printf("The thickness of Cd foil is = %f cm",x)
```

Scilab code Exa 5.18 P5 18

```
1
2 // Ex5_18
3 clc;
4
5 // Given:
6 a=3.8*1000*10^-24;// in barns
7 Ir=0.004;// I0/Ix
8 d=2.55;// g/cm^3
9
10 // Solution:
11 n=(d*6.02*10^23)/10;// atoms/cm^2
12 y=(Ir)^-1;
13 x=log(y)/(n*a);// in cm
```

```
14 printf("The thickness of B foil is = %f cm",x)
```

Scilab code Exa 5.19 P5 19

```
1
2 // Ex5_19
3 clc;
4
5 // Given:
6 E1=6;// MeV
7 mAl=26.981535;
8 malpha=4.002604;
9 mP=30.973763;
10 // Solution:
11
12 KE=E1*(27/31);// in MeV
13
14 BE=(mAl+malpha-mP)*931;// in MeV
15
16 Ex=KE+BE;
17
18 printf("\n The excitation energy of compound nucleus
     is = %f MeV",Ex)
```

Scilab code Exa 5.20 P5 20

```
1
2 // Ex5_20
3 clc;
4 // Given:
5 E1=1.4;// MeV
6 mBi=208.980417;
7 mn=1.008665;
```

```
mBI=209.984110;
// Solution:part(a)

KE1=0;// in MeV
BE1=(mBi+mn-mBI)*931;// in MeV
Ex1=KE1+BE1;
printf("\n The excitation energy of compound nucleus
    is = %f MeV",Ex1)

// Solution:part(b)

KE2=E1*(209/210);// in MeV
BE2=(mBi+mn-mBI)*931;// in MeV
Ex2=KE2+BE2;
printf("\n The excitation energy of compound nucleus
    is = %f MeV",Ex2)
```

Scilab code Exa 5.21 P5 21

```
// Ex5_21
clc;
Ex=12.8;// MeV
mB=10.012939;
malpha=4.002604;
mN=14.003074;
mC=12.00;
md=2.014102;
// Solution:part(a)

BE1=(mB+malpha-mN)*931;// in MeV
KE1=Ex-BE1;
E1=KE1*(14/10);
printf("\n The resonance in part(a) will occur at =
   %f MeV",E1)
```

```
16
17 // Solution:part(b)
18
19
20 BE2=(mC+md-mN)*931;// in MeV
21 KE2=Ex-BE2;
22 E2=KE2*(14/12);
23
24 printf("\n The resonance in part(b) will occur at =
   %f MeV",E2)
```

Scilab code Exa 5.22 P5 22

```
1
2 // Ex5_22
3 clc;
4
5 // Given:
6 B=2.5;// tesla
7 q=1.6*10^-19;
8 m=1.66*10^-27;
9
10 // Solution:
11
12 f=(B*q*10^-6)/(2*3.14*2*m);
13
14 printf("The resonance frequency is = %f MHz",f)
```

Scilab code Exa 5.23 P5 23

```
1
2 // Ex5_23
3 clc;
```

```
4
5 // Given:
6 f=8.6*10^6;// in Hz
7 q1=1.6*10^-19;
8 q2=6*1.6*10^-19;
9 m1=1.66*10^-27;
10 m2=14*1.66*10^-27;
11 // Solution:
12 // for proton
13 B1=2*3.14*f*m1/q1;
14
15 printf("\n The magnetic field needed to accelerate
     protons is = %f T",B1)
16 // for N(14) ions
17 B2=2*3.14*f*m2/q2;
18
19 printf("\n The magnetic field needed to accelerate N
     (14) ions is = %f T",B2)
```

Scilab code Exa 5.24 P5 24

```
1
2 // Ex5_24
3
4 clc;
5
6 E1=2.75;// MeV
7 E2=14;// in MeV
8 mMg=23.985045;
9 malpha=4.00260;
10 mSi=27.9763;
11 mNe=19.99244;
12 mCo=58.93320;
13 mRb=78.9239
14 // Solution:
```

```
15
16 KE1=E1*(24/28);// in MeV
17
18 BE1=(mMg+malpha-mSi)*931;// in MeV
19
20 Ex1=KE1+BE1;
21
22 printf("\n The excitation energy of compound nucleus
       Si* is = %f MeV",Ex1)
23 KE2=E2*(59/79);// in MeV
24
25 BE2=(mNe+mCo-mRb)*931;// in MeV
26
27 Ex2=KE2+BE2;
28
29 printf("\n The excitation energy of compound nucleus
       Rb*  is = %f MeV",Ex2)
```

Chapter 6

Nuclear Chemistry through Problems

Scilab code Exa 6.1 P6 1

```
1
2 //Ex6_1
3 clc;
4 // Given:
5 d1=7.9;// density of Gd
6 d2=2.31;// Density of In
7 a1=49;// in Kb
8 a2=155;// in b
9 m1=157.25;
10 m2=114.8;
11 Na=6.02*10^23;
12 // Solution:
13 x1=log(1/(1/2))/((d1*Na*a1*10^-24*10^3)/m1);// half-
     thickness for Gd
14
15
16 x2=log(1/(1/2))/((d2*Na*a2*10^-24)/m2);// half-
     thickness for In
17
```

```
18 r=x2/x1;
19 printf("The half-thickness of In is %f times more
      than of Gd.",r)
```

Scilab code Exa 6.2 P6 2

```
1
2 // Ex6_2
3
4 clc;
5
6 // Given:
7 d1=12;// density of Gd
8 a1=43.11;// in b
9 m1=106.4;
10 Na=6.02*10^23;
11 i1=1;
12 i2=1/1000;
13 // Solution
14
15 x=log(i1/i2)/((d1*Na*a1*10^-24)/m1);// thickness for
       Pd foil
16
17 printf("The thickness of Pd foil which would reduce
      the intensity of a beam to excatly 1/1000 of its
      initial value is = %f cm",x)
```

Scilab code Exa 6.3 P6 3

```
1 // Ex6_3
2
3 clc;
4
```

```
5 // Given:
6 mTe=129.9067; // mol wt. of Te(52)
7 mCu=64.9278;// mol wt of Cu(29)
8 mFe=65;// mol wt of Fe(26)
9 // Solution
10 E1=(mTe-2*mCu)*931; // Fission Energy in MeV
11 printf("The fission energy of Te(130)in MeV is = %f"
     ,E1)
12 r=((65)^0.33333);
13 E2=(26*26*4.8*4.8*10^-20)/(2*1.5*1.6*10^-13*10^-6*r)
     ;// Barrier energy in MeV
14 printf("\n The barrier energy of Te(130) in MeV is =
     %f",E2)
15 E3=E2-E1;// Activation Energy in MeV
16 printf("\n The activation energy of Te(130) in MeV
     is = %f",E3)
17
18 // Since barrier energy is greater than fission
     energy, spontaneous fission is not possible
     unless the activation energy is provided.
```

Scilab code Exa 6.4 P6 4

```
1
2 // Ex6_4
3 clc;
4 // Given:
5 mSn=113.903; // mol wt. of Sn(50)
6 mMn=56.9383;// mol wt of Mn(25)
7 mFe=57;//mol wt of Fe(26)
8 // Solution
9 E1=(mSn-2*mMn)*931; // Fission Energy in MeV
10 printf("\n The fission energy in MeV is = %f",E1)
11 r=((mFe)^0.33333);
12 E2=(25*25*4.8*4.8*10^-20)/(2*1.5*1.6*10^-13*10^-6*r)
```

```
   ;// Barrier energy in MeV
13 printf("\n The barrier energy in MeV is = %f",E2)
14 E3=E2-E1;// Activation Energy in MeV
15 printf("\n The activation energy in MeV is = %f",E3)
```

Scilab code Exa 6.5 P6 5

```
1
2 // Ex6_5
3 clc;
4 // Given:
5 a1=94;// atomic no. of Pu
6 a2=42;//atomic no. of Mo
7 a3=56;// atomic no. of Ba
8 // Solution:
9 // By principle of equal charge displacement
10 z1=0.5*(a1+a2-a3);
11 printf("\n z1=%f",z1)
12 z2=0.5*(a1-a2+a3);
13 printf("\n z2=%f",z2)
14
15 //From z1 and z2 we have the primary fragments as Zr
   (40), atomic mass(100) and Xe(54), atomic mass
   (138).
```

Scilab code Exa 6.6 P6 6

```
1
2 // Ex6_6
3 clc;
4 // Given:
5 a1=92;// atomic no. of U
6 a2=40;//atomic no. of Zr
```

```
7 a3=58;// atomic no. of Ce
8 // Solution
9 // By principle of equal charge displacement
10 z1=0.5*(a1+a2-a3);
11 printf("\n z1=%f",z1)
12 z2=0.5*(a1-a2+a3);
13 printf("\n z2=%f",z2)
14 //From z1 and z2 we have the primary fragments are
     Rb(37), atomic mass(94) and Cs(55), atomic mass
     (140).
```

Scilab code Exa 6.7 P6 7

```
1
2
3 // Ex6_7
4 clc;
5 // Given:
6 a1=92;// atomic no. of U
7 a2=42;//atomic no. of Mo
8 a3=56;// atomic no. of Ba
9 // Solution
10 // By principle of equal charge displacement
11 z1=0.5*(a1+a2-a3);
12 printf("\n z1=%f",z1)
13 z2=0.5*(a1-a2+a3-4);
14 printf("\n z2=%f",z2)
15
16 // From z1 and z2 we have the primary fragments are
     Y(39), atomic mass(95) and Sb(51), atomic mass
     (137)
```

Scilab code Exa 6.8 P6 8

```
1
2 // Ex6_8
3 clc;
4 // Given:
5 mU=236.04533;
6 mU1=236.045733;
7 mU2=235.043933;
8 mY=94.912;
9 mSb=136.91782;
10 mn=1.0087;
11 Na=6.02*10^23;
12
13 // Solution:
14 E1=(mU-mY-mSb-4*mn)*931; // Fission Energy in MeV
15 printf("The fission energy in MeV is = %f",E1)
16 r1=((mY)^0.33333);
17 r2=((mSb)^0.33333);
18 E2=(39*51*4.8*4.8*10^-20)/(1.5*10^-13*(r1+r2)
     *1.6*10^-6);// Barrier energy in MeV
19 printf("\n The barrier energy in MeV is = %f",E2)
20 E3=E2-E1;// Activation Energy in MeV
21 printf("\n The activation energy in MeV is = %f",E3)
22 // Note : There is discrepancy in the final answer.
23 E4=(mU2+mn-mU1)*931; // Fission Energy in MeV
24 printf("\n The fission by thermal neutrons is not
     possible since excitation energy %f is less than
      activation energy.",E4)
```

Scilab code Exa 6.9 P6 9

```
1
2 // Ex6_9
3 clc;
4 // Given:
5 nSr=38;
```

```
nY=39;


// Solution:

PSr=0.565*exp(-((nSr-40)^2)); //independent fractional chain yield of Sr
PY=0.565*exp(((nY-40)^2)); //independent fractional chain yield of Y

printf("The independent fractional chain yield of Sr is = %f",PSr)
printf("\n The independent fractional chain yield of Y is = %f",PY)
```

Scilab code Exa 6.10 P6 10

```
//Ex6_10

clc;
// Given:
mU=235.043091;
mn=1.0087;
mXe=138.9187;
mSn=94.919;

// Solution:
dm=(235.04309+1.0087-138.917-94.919-2.0174);// delta m
E=dm*931;// energy of given fission in MeV
printf("The energy for the given fission is = %f MeV",E)
```

Scilab code Exa 6.11 P6 11

```
1
2 //Ex6_11
3 clc;
4 // Given:
5 mPu=239.052161;
6 mPd=107.903920;
7 mXe=128.904784;
8 mn=1.0087;
9 mGd=154.922010;
10 mBr=80.916344;
11
12 // Solution: Part (a)
13
14 dm1=(mPu-(mPd+mXe+2*mn));// delta m
15 E1=dm1*931;// energy of given fission in MeV
16 printf("The energy for the Pd(108)+Xe(129)+3n
   fission is = %f MeV",E1)
17
18 dm2=(mPu-(mGd+mBr+3*mn));// delta m
19 E2=dm2*931;// energy of given fission in MeV
20 printf("\n The energy for the Gd(155)+Br(81)+4n
   fission is = %f MeV",E2)
```

Scilab code Exa 6.12 P6 12

```
1
2 // Ex6_12
3 clc;
4 // Given:
5
```

```
mFm=250.079;
mSn=124.9077;
Na=6.02*10^23;

// Solution:
E1=(mFm-2*mSn)*931; // Fission Energy in MeV
printf("The fission energy in MeV is = %f",E1)

r=((mSn)^0.33333);
E2=(50*50*4.8*4.8*10^-20)/(2*1.5*10^-13*(r)
   *1.6*10^-6);// Barrier energy in MeV
printf("\n The barrier energy in MeV is = %f",E2)
```

Scilab code Exa 6.13 P6 13

```

// Ex6_13
clc;
// Given:
mTh1=232;
mTh2=233;
ETh1=6.4;// in MeV
ETh2=4.93;// in MeV
E=6.5;// fission barrier energy in MeV

// Solution: Part(a)
E1=0*mTh1/mTh2;
Ex1=E1+ETh2;
printf("\n (a) Excitation energy is = %f MeV",Ex1)
if (Ex1>E) then
    printf("\n Fission is possible")
else
    printf("\n Fission is not possible")
end

```

```
// Solution: Part(b)
E2=2*mTh1/mTh2;
Ex2=E2+ETh2;
printf("\n (b) Excitation energy is = %f MeV",Ex2)
if (Ex2>E) then
    printf("\n Fission is possible")
else
    printf("\n Fission is not possible")
end

// Solution: Part (c)
E3=10*mTh1/mTh2;
Ex3=E3+ETh2;
printf("\n (c) Excitation energy is = %f MeV",Ex3)
if (Ex3>E) then
    printf("\n Fission is possible")
else
    printf("\n Fission is not possible")
end
```

Scilab code Exa 6.14 P6 14

```

// Ex6_14

clc;

// Given:

mEs=249.0762;
mn=1.0087;
mGd=160.9286;
mBr=86.922;

// Solution:
```

```
14 dm=(mEs-(mGd+mBr+mn));// delta m
15 E=dm*931;// energy of given fission in MeV
16 printf("The energy for the given fission is = %f MeV
   ",E)
```

Scilab code Exa 6.15 P6 15

```
1
2 // Ex6_15
3
4 clc;
5
6 // Given:
7
8 m=1/6;// mass ratio of pair of fission product
9
10 // Solution:
11 // Velocities as well as energies are in inverse
   ratio of their masses.
12
13 v=(m)^(-1);// Velocity ratio
14 e=(m)^(-1);// Energy ratio
15 printf("The velocity will be related as %f and
   Energy will be related as %f",v,e)
```

Scilab code Exa 6.16 P6 16

```
1
2 // Ex6_16
3
4 clc;
5
6 // Given:
```

```
P=100;// in watts

// Solution:
P1=P*10^7;// in erg/s
P2=P1/(1.6*10^-6);// in MeV/s
// 1 ifssion generates 200 MeV of energy
f=P2/200;// no. of fissions

printf("The no. of fissions produced per second will
    be = %f",f)
```

Scilab code Exa 6.17 P6 17

```
1
2 // Ex6_17
3 clc;
4 // Given:
5 r0=1.4*10^-15;// nuclear radius constant in m
6 p=8.85*10^-12;// permittivity of free space in J^-1*
    C^2*m^-1
7 A=92;
8 e=1.6*10^-19;
9 mPd=118;
10 // Solution:
11 r=((mPd)^0.33333);
12 Eb=((A/2)^2)*(e^2)/(2*r0*r*4*3.14*p*1.6*10^-13);
13 printf("The fission barrier energy is = %f MeV",Eb)
```

Scilab code Exa 6.18 P6 18

```
1
2 // Ex6_18
3 clc;
```

```
4
5 // Given:
6 r0=1.37*10^-15;// nuclear radius constant in m
7 p=8.85*10^-12;// permittivity of free space in J^-1*
    C^2*m^-1
8 A=92;
9 e=1.6*10^-19;
10 mTe=140;
11 mZr=95;
12 // Solution:
13 r1=((mTe)^0.33333);
14 r2=((mZr)^0.33333);
15 Eb=(52*40)*(e^2)/(r0*(r1+r2)*4*3.14*p*1.6*10^-13);
16 printf("The fission barrier energy is = %f MeV",Eb)
```

Scilab code Exa 6.19 P6 19

```
1
2 // Ex6_19
3 clc;
4
5 // Given:
6 A=240;
7 Z=94;
8 //Solution:
9 Ecr=(0.89*(A^(2/3)))-(0.02*(Z*(Z-1)))/(A^(1/3));
10 printf("The critical deformation energy for the
    fission is = %f MeV",Ecr)
```

Chapter 7

Nuclear Chemistry through Problems

Scilab code Exa 7.1 P7 1

```
1 // Ex7_1
2
3 clc;
4
5 // Given:
6
7 f=1.03;// fast fission factor
8 n=1.32;// no. of fast neutrons generated per thermal
      radiations
9 ref=0.89;// resonance escape factor
10 tuf=0.87;// thermal utilization factor
11
12 // Solution
13
14 rf=f*n*ref*tuf;//reproduction factor
15
16 printf("The reproduction factor for the reactor is =
      %f",rf)
```

Scilab code Exa 7.2 P7 2

```
1
2 // Ex7_2
3
4 clc;
5
6 // Given:
7 k=1.04;
8 m=0.032;// in m^2 i.e., migration area M^2
9
10 // Solution: (a) Cubical reactor
11 a=3.14*sqrt(3*m/(k-1));
12
13 printf("\n The approximate critical dimensionsof a
   Pu 239 is = %f m",a)
14
15
16 // Solution: (a) Spherical reactor
17 r=a/sqrt(3);
18
19 printf("\n \n The radius of the reactor is = %f m",r
   )
```

Scilab code Exa 7.3 P7 3

```
1
2 // Ex7_3
3
4 clc;
5
6 // Given:
```

```
7 a1=687; // neutron absorption cross section for U
     235 in barns
8 a2=0.66 // neutron absorption cross section for H2O
     in barns
9 a3=0.0093; // neutron absorption cross section for
     D2O in barns
10 a4=0.0045; // neutron absorption cross section for C
     in barns
11
12 //Solution:
13
14 F1=1.07*a1/a2;//design parameter for H2O part(a)
15 printf("\n The design parameter for H2O is = %f",F1)
16
17 F2=1.07*a1/a3;//design parameter for D2O part(b)
18 printf("\n \n The design parameter for D2O is = %f",
     F2)
19
20 F3=1.07*a1/a4;//design parameter for C part(c)
21 printf("\n \n The design parameter for C is = %f",F3
     )
```

Scilab code Exa 7.4 P7 4

```
1 // Ex7_4
2
3 clc;
4
5 // Given:
6 P=10*10^6; // power in watts
7 E=200*10^6; // in eV
8
9 // Solution:
10 e=E*1.6*10^-19;// in joules
11 // Thus for 1 fission occurs per second, rate of
```

```
    power generation is e
n=(P)/e;// no. of fissions
printf("The no. of fissions per second are = %f",n)
```

Scilab code Exa 7.5 P7 5

```
1
2 // Ex7_5
3
4 clc;
5
6 // Given:
7 density=19;// in g/cc
8 E1=200*10^6*(1.6*10^-19); // energy released per
    fission in J
9 flux1=10^12;// in cm^2/s
10 a1=590*10^-24;//fission cross-section in cm^2
11 Na1=6.02*10^23;
12
13 // Solution:
14
15 //Ntgt=volume of target*No.of atoms per cm^3
16
17 Ni=(30*((0.5)^2)*3.14*density*Na1*(0.72*10^-2))/238;
18
19 Np=Ni*a1*flux1;
20
21 E2=E1*Np;// Thermal energy generated in J
22
23 printf("\n The thermal energy generated is = %f J",
    E2)
24 // Note: There is discrepancy in answer given in the
     textbook. After calculations the answer comes
    out to be 153.850366 J
```

Chapter 8

Nuclear Chemistry through Problems

Scilab code Exa 8.1 P8 1

```
1
2 //Ex8_1
3 clc;
4
5 //Given:
6 e=1.6*10^-19;// electron charge
7 C=6*10^-12;// in F
8 N=10^5;// // electron multiplication
9 //Solution:
10 e1=N*e;
11 v=e1/(2*C);
12 v1=1000*v;
13   printf("The potential signal recorded will be = %f
       mV",v1)
```

Scilab code Exa 8.2 P8 2

```
// Ex8_2
clc;

// Given:
N=10^5;// electron multiplication
v=10^-6;// in V
e=1.6*10^-19;// electron charge

// Solution:
e1=N*e;
C=e1/(2*v);
C1=C*10^9;
printf("The capacitance that would be required is =
   %f nF",C1)
```

Scilab code Exa 8.3 P8 3

```
// Ex8_3

clc;

// Given:
n0=1;// initial primary electrons
n=1.6*10^4;
x=2.2; //distance in cm

// Solution:
a=log(n/n0)/(x);

printf("The alpha coefficient is = %f electrons
   electron^-1 cm^-1",a)
```

Scilab code Exa 8.4 P8 4

```
// Ex8_4
clc;
// Given:
V=1600;// potential across the electrodes
di=3;// inner diameter
do=40;// outer diameter
a=1.5;//in mm
A=20;//in mm

// Solution:
// Part(a)At the inner surface
r1=1.5;// in mm
V1=V*(log(A/r1)/log(A/a));
X1=V/(r1*(log(A/a)));
printf("\n The potential at the inner surface is =
   %f V",V1)
printf("\n The field at the inner surface is = %f V/
   cm",X1)
// Part(b)At the outer surface
r2=20;// in mm
V2=V*(log(A/r2)/log(A/a));
X2=V/(r2*(log(A/a)));
printf("\n \n The potential at the outer surface is
   = %f V",V2)
printf("\n The field at the outer surface is = %f V/
   cm",X2)
// Part(c)In mid-way between the cylinder
r3=(A+a)/2;// in mm
V3=V*(log(A/r3)/log(A/a));
X3=V/(r3*(log(A/a)));
printf("\n \n The potential in mid-way between the
   cylinder is = %f V",V3)
printf("\n The field in mid-way between the
   cylinderis = %f V/cm",X3)
```

Scilab code Exa 8.5 P8 5

```
1
2 // Ex8_5
3 clc;
4 // Given:
5 ma1=3600;// counts in 3 min
6 mb1=2400;// counts in 5 min
7 mab1=9900;// counts in 6 min
8
9 // Solution:
10 ma=ma1/3;
11 mb=mb1/5;
12 mab=mab1/6;
13
14 t1=(ma+mb-mab)/(mab^2-ma^2-mb^2);
15 t2=t1*60;// in seconds
16 t=t2*1000000;// in microseconds
17 printf("The resolving time of the given system in
   microseconds is = %f",t)
```

Scilab code Exa 8.6 P8 6

```
1
2 // Ex8_6
3 clc;
4 // Given:
5 ma1=3321;// counts in 3 min
6 mb1=2862;// counts in 2 min
7 mab1=4798;// counts in 2 min
8 m=1080;// counts in 30 min
9 muk1=5126;// counts in 2 min
```

```
10 // Solution:
11 ma=ma1/3;
12 mb=mb1/2;
13 mab=mab1/2;
14 mbc=m/30;
15 muk=muk1/2;
16 t1=(ma+mb-mab-mbc)/(mab^2-ma^2-mb^2);// in min
17 t2=t1*60;// in seconds
18 t=t2*1000000;// in microseconds
19 printf("The resolving time of the given system in
      microseconds is = %f",t)
20
21 n=muk/(1-muk*t1);// true count rate
22
23 printf("\n The true count rate of unknown sample is
      = %f cpm",n)
```

Scilab code Exa 8.7 P8 7

```
1
2 // Ex8_7
3 clc;
4
5 // Given:
6
7 ma=9728;// cpm
8 mb=11008;// cpm
9 mab=20032;// cpm
10
11 // Solution:
12
13 t1=(ma+mb-mab)/(mab^2-ma^2-mb^2);// in min
14
15 t2=t1*60;// in seconds
16 t=t2*1000000;// in microseconds
```

```
17 printf("\n The resolving time of the given system in
       microseconds is = %f",t)
18
19 //From true count rate equation we have, n=muk/(1-
   muk*t).
20 // This implies, n-m=m^2*t where n-m corresponds to
   counting loss
21 na=ma^2*t1;// For sample A
22 nb=mb^2*t1;// For sample B
23 nab=mab^2*t1;// For sample AB
24
25 printf("\n \n The counting loss of sample A is = %f
   cpm",na)
26
27 printf("\n \n The counting loss of sample B is = %f
   cpm",nb)
28
29 printf("\n \n The counting loss of sample AB is = %f
     cpm",nab)
30 // NOTE: The resolving time of the given system in
   microseconds is give 222.7. This is a calculation
     error in the textbook.
```

Chapter 9

Nuclear Chemistry through Problems

Scilab code Exa 9.1 P9 1

```
1
2 //Ex9_1
3
4 clc;
5
6 //Give:
7 t=3600;// in seconds
8 F=96500;// in columbs
9 // Formula: m=0.0373fMit, Faraday's law: m=(itE)/F
10
11 //Solution:
12 constant=t/F;
13 printf("The value of numerical constant is = %f",
     constant)
```

Scilab code Exa 9.2 P9 2

```
1
2 //Ex9_2
3 clc;
4 // Given:
5 m1=24*10^-6;// g per day
6 m2=10^-2;// g per day
7 i1=10^-6;// in A
8
9 //Formula: i1*m2=m1*i2
10
11 //Solution:
12
13 i2=(i1*m2)/m1;
14 i=i2/10^-3;// in mA
15
16 printf("The ion current should be = %f mA",i)
```

Scilab code Exa 9.3 P9 3

```
1 //Ex9_3
2 clc;
3 //Given:
4 f=1.0014;// seperation factor
5 s=4;// series
6 p=6;// parallel
7
8 // Note: The global yield for s stages in series is(
     f)^s and each parallel stages simply multiplies
     the yield of the stage, Hence overall yield with
     p parallel stages (each with s stages in series)
     will be Y=p*(f)^s
9
10 //Solution:
11 Y=p*(f)^s;
12
```

```
13 printf("The net yield is = %f",Y)
```

Scilab code Exa 9.4 P9 4

```
1
2 // Ex9_4
3
4 clc;
5
6 // Given:
7 f=1.0014;// seperation factor
8
9 //Solution: Part (a)
10 A1=3.5/0.72;// total enrichment
11 n1=log(A1)/log(f);
12 printf("\n The no. of stages will be = %d", n1)
13
14 //Solution: Part (b)
15 A2=90/0.72;// total enrichment
16 n2=log(A2)/log(f);
17 printf("\n \n The no. of stages will be = %d", n2)
```

Scilab code Exa 9.5 P9 5

```
1 //Ex9_5
2
3 clc;
4
5 // Given:
6 f=1.01;// seperation factor
7 n=10;// plates
8 //Solution:
9
```

```
10 A=f^n;
11
12 printf("The overall seperation factor is = %f",A)
```

Scilab code Exa 9.6 P9 6

```
1 //Ex9_6
2
3 clc;
4
5 // Given:
6 f=1.01;// seperation factor
7 n=16;// plates
8 //Solution:
9
10 A=f^n;
11
12 printf("The overall seperation factor is = %f",A)
```

Scilab code Exa 9.7 P9 7

```
1 //Ex9_7
2
3 clc;
4
5 // Given:
6
7 k1=3.78;
8 k2=2.79;
9 t1=298;// in K
10 t2=353;// in K
11 R=8.314// Gas constant
12
```

```
13 // Formula: log(k1/k2)=(H/R)*((t2-t1)t1*t2)
14
15 // Solution:
16
17 H=R*log(k1/k2)/((t2-t1)/(t1*t2));
18
19 printf("The enthalpy for the exchange reaction is =
     %f J",H)
```

Scilab code Exa 9.8 P9 8

```
1
2 // Ex9_8
3
4 clc;
5
6 // Given:
7 a1=0.015;
8 a2=0.04;
9
10 // Solution: Defining the seperation factor f as
     approximately equal to (a2/a1) where a1, a2 are
     the relative abundances of the isotope of
     interest in the initial and final fractions, we
     have
11
12 f=(a2/a1);
13
14 printf("The single stage seperation factor is = %f",
     f)
```

Chapter 10

Nuclear Chemistry through Problems

Scilab code Exa 10.1 P10 1

```
1 //Ex10_1
2
3 clc;
4
5 // Given:
6 E=4.8;// in MeV
7 M=128;// molecular weight of I
8
9 //Formula:
10 // Er=(536*E^2)/M
11
12 // Solution:
13
14 Er=(536*E^2)/M;
15
16 printf("The energy of recoil of Iodine atom is = %f
   eV", Er)
```

Scilab code Exa 10.2 P10 2

```
1
2 //Ex10_2
3
4 clc;
5
6 // Given:
7 E=1.1;// in MeV
8 M=65;// molecular weight of zinc
9
10 //Formula:
11 // Er=(536*E^2)/M
12
13 // Solution:
14
15 Er=(536*E^2)/M;
16
17 printf("The energy of recoil of Zinc atom is = %f eV
   ", Er)
```

Scilab code Exa 10.3 P10 3

```
1 //Ex10_3
2
3 clc;
4
5 // Given:
6 M1=137.32;// moleular wt of barium
7 M2=32;// molecular weight of sulphur
8 M3=16;// molecular wt of oxygen
9 M4=233.32;// molecular wt of BaSO4
```

```
10 ai=40000;// specific initial activity in counts min
   ^-1 mg^-1
11 af=187/20;// specific final activity in counts min
   ^-1 0.1ml^-1
12
13 // Formula:
14 // (1)S1=(af/ai)*(10/M) in moles/lit
15 // (2)S2=(af/ai)*(10^4) in mg/lit
16
17 // Solution:
18
19 S1=(af/ai)*(10/M4); // solubility of BaSO4 in moles/
   lit
20 S2=(af/ai)*10^4;// solubility of BaSO4 in mg/lit
21 printf("\n The solubility of BaSO4 in moles/lit is =
    %f",S1)
22 printf("\n \n The solubility of BaSO4 in mg/lit is =
    %f",S2)
```

Scilab code Exa 10.4 P10 4

```
1 //Ex10_4
2
3 clc;
4
5 // Given:
6 conc=4;// 4 mg per 1 l
7 a1=1600;// labelled solution of PbSO4
8 a2=900;// activity of filtrate (in solution)
9 M=303.2;// molecular wt of PbSO4
10 l=6.022*10^23;
11 // Solution:
12 y=20*4/1000;// 20 ml will contain y mg
13 z=y*a2/a1;// final amount of PbSO4 in solution
14 a3=a1-a2;// activity on surface
```

```
15 // Let the total PbSO4 on surfaceof precipitate be x
16 // Asumming exchange equilibrium is established we
      have
17
18 x=a3*z/a2;// in mg
19 molecules=x*10^-3*(1)/M;
20 // Give that surface area of 1 PbSO4 = 18.4*10^-16
      cm^2
21 A=molecules*18.4*10^-16;
22
23 printf("The surface area of 1 gm of precipitate
      sample is = %f cm^2/gm",A)
```

Scilab code Exa 10.5 P10 5

```
1 //Ex10_5
2
3 clc;
4
5 // Given:
6 ai=14000;// counts per min per 0.1 cm^3, initial
      activity of blood
7 Si=1.4*10^5;// c min^-1 cm^-3, initial specific
      activity
8 a=250;// 250 net counts in 10 min, this implies 25
      net counts in a min
9
10 // Formula: Si/Sr = V
11
12 // Solution:
13 V=Si/25;// total blood in the patient in cm^3
14 V1=V/1000;// volume in lit
15 printf("The volume of blood in the patient is = %f
      lit",V1)
```

Scilab code Exa 10.6 P10 6

```
1 //Ex10_6
2
3 clc;
4
5 // Given:
6 y=5;// in mg labelled sample
7 V=2000;// volume of mixture in ml
8 // Formula: x=y*(Si-Sf)/Sf
9 //Solution:
10
11 Si=20000/(5*5);// initial specific activity in
     counts min^-1 mg^-1
12 Sf=3000/(.6*10);// final specific activity in counts
     min^-1 mg^-1
13 x=y*(Si-Sf)/Sf;// in mg for V amount of volume
14 //% of penicillin in mixture
15 p=x*100/V;
16
17 printf("The percentage of penicillin in mixture is =
     %f ",p)
```

Scilab code Exa 10.7 P10 7

```
1 //Ex10_7
2
3 clc;
4
5 // Given:
6 y=2;// in ml labelled sample
7 V=1000;// volume of mixture in ml
```

```
8 BC=100/20;// 100 counts for 20 min
9
10
11 // Formula: x=y*(Si-Sf)/Sf
12
13 //Solution:
14
15 Si=(2500-BC)/(2);// initial specific activity in
      counts min^-1 mg^-1
16 Sf=(600-BC)/(3);// final specific activity in counts
       min^-1 mg^-1
17 x=y*(Si-Sf)/Sf;// in mg for V amount of volume
18 //% of iodine in mixture
19 i=x*100/V;
20
21 printf("The percentage of iodine in mixture is = %f
      ",i)
22
23 //NOte: Backward counts are taken to be 100 counts
      for 10 min in the solution given in textbook
```

Scilab code Exa 10.8 P10 8

```
1 //Ex10_8
2
3 clc;
4
5 // Given:
6 flux=10^12;
7 s=15.9*10^-24;
8 m1=0.5;// weight of ruby in mg
9
10 //Soluton:
11
12 a1=35000;// measured activity in c/s
```

```
13
14 a2=350000;// corrected activity in )d/s
15
16 N=a2/(flux*s*(1-0.5^(1/27.7)));
17
18 m=50*N/(6.02*10^23);
19
20 Cr=(100*m)/4.35;// total Cr in in the Ruby
21
22 crp=(Cr*100)/0.5;// % cr in the ruby
23
24 printf("The percentage Cr content in the ruby is =
     %f ",crp)
```

Scilab code Exa 10.9 P10 9

```
1
2 //Ex10_9
3
4 clc;
5
6 // Given:
7
8 flux=10^12;
9 s=3.28*10^-27;
10 hf=1;// half life in min
11 //Soluton:
12
13 a1=2500;// measured activity in d/s
14
15 a2=5000;// corrected activity in d/s
16
17 N=a2/(flux*s);
18
19 m=76*N/(6.02*10^23);
```

```
20
21 Cr=(100*m)/7.8;// total mass of Ge atoms (isotopic
      abandunce is 7.8%)
22
23 printf("The total mass of Ge atoms present in sample
      is = %f g",Cr)
```

Scilab code Exa 10.10 P10 10

```
1
2 //Ex10_10
3
4 clc;
5
6 // Given:
7 M=55;// wt of Mn
8 m=0.1;// in g
9 t=90;// min irradated
10 flux=10^6;
11 t1=5; //in hours
12 cs=13.3*10^-24// in cm^2
13 hl=2.58;// in hours
14 Na=6.022*10^23;
15 r=100;// in %
16 // Solution:
17 s=1-(exp(-.693*t/(2.58*60)));
18 A=(m*Na*r*flux*cs*s)/(100*M);
19 x=exp(-0.693*5/2.58);
20 // activity after cooling period
21
22 A1=A*x*60;// in  dpm
23 printf("The activity of sample in dpm is = %f", A1)
```

Scilab code Exa 10.11 P10 11

```
1 //Ex10_11
2 clc;
3 // Given:
4 t1=12.7;// in hours
5 a=4.5*10^-24;// in cm^2
6 r=69.1;//in %
7 cf=10;// in %
8 flux=10^6;
9 Na=6.022*10^23;
10 cpm=1500;// activity in counts per min
11 M=63;
12 //Solution:
13 dpm=cpm*100/10;
14 dps=dpm/60;
15 x=exp(-0.693*5/t1);
16 A=dps/x;
17
18 s=1-(exp(-.693*10/(12.7)));
19 w=(A*M*100)/(Na*r*a*flux*s);// gms of Cu
20
21 // given that 5g Cu in 100g alloy, for wg amount of
   alloy will be
22
23 Y=100*w/5;// amount of alloy ing
24
25 printf("\n The weight of the sample that should be
   taken is = %f g",Y)
```

Scilab code Exa 10.12 P10 12

```
1
2 // Ex10_12
3 clc;
```

```
4 // Given:
5 vi=2.5;//titrant volume
6 V1=10; // vol of KBr in ml
7 N2=0.01;//normality of AgNO3
8 M1=119;// mol wt of KBr
9 // Solution:
10 ai=((12500/5)-10);
11 af=((6000/6)-10);
12 // deerease in activity due to addition of titrant
     2.5ml
13 d=ai-af;
14 // volume corresponding to ai for AgNO3
15 V2=ai*vi/d;
16 N1=(N2*V2)/V1;// Normality of KBr solution
17
18 m=N1*M1/100;// mass of KBr in 10 ml solution
19
20 printf("\n The mass of potassium bromide in the
     original solution is = %f g",m)
```

Scilab code Exa 10.13 P10 13

```
1
2 // Ex10_13
3
4 clc;
5
6 // Given:
7 w=5;// in g
8 ai=55;// counts per 10 min
9 A0=15.8;// in dpm/g
10 // Solution:
11
12 cpm=55/10;
13 dpm=cpm*100/10; // 10% efficient counting
```

```
14 sa=dpm/w;// in dpm/g
15 t=5730*log(A0/sa)/(0.693); // Age determination
16
17 printf("The age of the sample is = %f years",t)
```

Chapter 11

Nuclear Chemistry through Problems

Scilab code Exa 11.1 P11 1

```
1
2 //Ex11_1
3
4 clc;
5
6 //Given:
7 density1=1.000;// for water in CGS units
8 density2=0.789;// for ethanol in CGS units
9 density3=0.793;// for methanol in CGS units
10 l=6.023*10^23;// avogadro constant
11 ue=0.211;// electron absorption coefficent in barn
     per electron
12 // 1 b=10^(-24) cm^2
13
14
15 //solution: (a) Water
16
17 z1=10;// no. of electrons
18 a1=18;// atomic mass of water
```

```
19 uw=ue*z1;//molecule absorption coefficient
20 umw=(uw*1*10^-24)/a1;//mass absorption coefficient
21 ulw=umw*density1;// linear absorption coefficient
22
23 printf("\n The molecule absorption coefficient of
      water in b/molecule is = %f ",uw)
24 printf("\n The mass absorption coefficient of water
      in cm^2/g is = %f ",umw)
25 printf("\n The linear absorption coefficient of
      water in cm^-1 is = %f ",ulw)
26
27 //solution: (b) ethanol
28
29 z2=26;// no. of electrons
30 a2=46;// atomic mass of water
31 ueth=ue*z2;//molecule absorption coefficient
32 umeth=(ueth*1*10^-24)/a2;//mass absorption
      coefficient
33 uleth=umeth*density2;// linear absorption
      coefficient
34
35 printf("\n \n The molecule absorption coefficient of
       ethanol in b/molecule is = %f ",ueth)
36 printf("\n The mass absorption coefficient of
      ethanol in cm^2/g is = %f ",umeth)
37 printf("\n The linear absorption coefficient of
      ethanol in cm^-1 is = %f ",uleth)
38
39 //solution: (c) methanol
40
41 z3=18;// no. of electrons
42 a3=32;// atomic mass of water
43 umet=ue*z3;//molecule absorption coefficient
44 ummet=(umet*1*10^-24)/a3;//mass absorption
      coefficient
45 ulmet=ummet*density3;// linear absorption
      coefficient
46
```

```
47 printf("\n \n The molecule absorption coefficient of
       methanol in b/molecule is = %f ",umet)
48 printf("\n The mass absorption coefficient of
     methanol in cm^2/g is = %f ",ummet)
49 printf("\n The linear absorption coefficient of
     methanol in cm^-1 is = %f ",ulmet)
```

Scilab code Exa 11.2 P11 2

```
1
2 //Ex11_2
3
4 clc;
5
6 //Given:
7
8 // for benzene in CGS units
9 density1=.879;
10 lac1=.06014; // linear absorption coefficient
11
12 // for cyclohexane in CGS units
13 density2=0.779;
14 lac2=.05656; // linear absorption coefficient
15 l=6.023*10^23;// avogadro constant
16 ue=0.211;// electron absorption coefficent in barn
     per electron
17 // 1 b=10^(-24) cm^2
18
19
20 //solution: (a)Benzene
21
22 a1=78;// atomic mass of benzene
23 mac1=lac1/density1; //mass absorption coefficient
24 mb=(mac1*a1)/(l*10^-24); //molecule absorption
     coefficient of benzene
```

```
25
26 printf("\n The molecule absorption coefficient of
      benzene in b/molecule is = %f ",mb)
27 printf("\n The mass absorption coefficient of
      benzene in cm^2/g is = %f ",mac1)
28
29
30 //solution: (b)cyclohexane
31
32 a2=84;// atomic mass of cyclohexane
33 mac2=lac2/density2; //mass absorption coefficient
34 mc=(mac2*a2)/(l*10^-24); //molecule absorption
      coefficient of cyclohexane
35
36 printf("\n \n The molecule absorption coefficient of
       cyclohexane in b/molecule is = %f ",mc)
37 printf("\n The mass absorption coefficient of
      cyclohexane in cm^2/g is = %f ",mac2)
```

Scilab code Exa 11.3 P11 3

```
1
2 //Ex11_3
3
4 clc;
5
6 //Given:
7 //Atomic absorption coefficients for diferent atoms
      in b/atom
8 O=1.69;
9 Na=2.32;
10 P=3.17;
11 Ca=4.22;
12 I=12.03
13 // 1 b=10^(-24) cm^2
```

```
14
15
16 //solution:
17 //mass absorption coefficient for the given atoms in
       cm^2/g
18
19 uO=(O*10^-24*6.022*10^23)/16;
20 uNa=(Na*10^-24*6.022*10^23)/23;
21 uP=(P*10^-24*6.022*10^23)/31;
22 uCa=(Ca*10^-24*6.022*10^23)/40;
23 uI=(I*10^-24*6.022*10^23)/127;
24
25 // The mass absorption coefficient for the given
      substance is the sum of the mass absorption
      coefficients of the atoms present, each atom
      being weighted in proportion to its mass in the
      molecule.
26
27 //(a) NaI(A1=150)
28 u1=(uNa*23+uI*127)/150;
29 //(b) NaIO3 (A2=198)
30 u2=(uNa*23+uI*127+uO*48)/198;
31 //(c) Ca(PO3)2 (A3=198)
32 u3=(uCa*40+uP*62+uO*96)/198;
33 //(d) Ca3(PO4)2 (A4=310)
34 u4=(uCa*120+uP*62+uO*128)/310;
35
36
37 printf("The mass absorption coefficient of NaI in cm
      ^2/g is = %f ",u1)
38 printf("\n \n The mass absorption coefficient of
      NaIO3 in cm^2/g is = %f ",u2)
39 printf("\n \n The mass absorption coefficient of Ca(
      PO3)2 in cm^2/g is = %f ",u3)
40 printf("\n \n The mass absorption coefficient of Ca3
      (PO4)2 in cm^2/g is = %f ",u4)
```

Scilab code Exa 11.4 P11 4

```
1
2 //Ex11_1
3
4 clc;
5
6 //Given:
7 density1=3.123;// for KI in CGS units
8 density2=3.168;// for KIO3 in CGS units
9 l=6.023*10^23;// avogadro constant
10 ue=0.211;// electron absorption coefficent in barn
     per electron
11 // 1 b=10^(-24) cm^2
12
13 //Atomic absorption coefficients for diferent atoms
     in b/atom
14
15 K=ue*19;
16 I=ue*53;
17 O=ue*8;
18
19 //mass absorption coefficient for the given atoms in
     cm^2/g
20
21 uK=(6.022*10^23*K*10^-24)/39;
22 uI=(6.022*10^23*I*10^-24)/127;
23 uO=(6.022*10^23*O*10^-24)/16;
24
25 //solution: (a)KI
26
27 uKI=K+I;//molecular absorption coefficient
28 umKI=(39*uK+127*uI)/166;//mass absorption
     coefficient
```

```
29 ulKI=umKI*density1;// linear absorption coefficient
30
31 printf("\n The molecular absorption coefficient of
      KI in b/molecule is = %f ",uKI)
32 printf("\n The mass absorption coefficient of KI in
      cm^2/g is = %f ",umKI)
33 printf("\n The linear absorption coefficient of KI
      in cm^-1 is = %f ",ulKI)
34
35 //solution: (b)KIO3
36
37 uKIO4=(K+I+O*4);//molecule absorption coefficient
38 umKIO4=(39*uK+127*uI+64*uO)/230;//mass absorption
      coefficient
39 ulKIO4=umKIO4*density2;// linear absorption
      coefficient
40
41 printf("\n \n The molecular absorption coefficient
      of KIO4 in b/molecule is = %f ",uKIO4)
42 printf("\n The mass absorption coefficient of KIO4
      in cm^2/g is = %f ",umKIO4)
43 printf("\n The linear absorption coefficient of KIO4
       in cm^-1 is = %f ",ulKIO4)
```

Scilab code Exa 11.5 P11 5

```
1
2 //Ex11_5
3
4 clc;
5
6 //Given:
7 i1=4000;// initial intensity of radiaton
8 i2=2000;// final intensity of radiation
9 density1=8.96;// density of copper
```

```
10 l=6.022*10^23;// avogadro constant
11 ue=0.211;// electron absorption coefficent in barn
      per electron
12 // 1 b=10^(-24) cm^2
13
14 //solution:
15
16 uCu=ue*29;//atomic absorbtion coefficient in b/atom
17 umCu=(6.022*10^23*uCu*10^-24)/63; // mass absorbtion
       coefficient in cm^2/g
18 ulCu=umCu*density1;// linear absorption coefficient
      in cm^-1
19
20 // we know that, i2=i1*exp(ulCu*x)
21
22 x=log(i1/i2)/(ulCu);// thickness of the copper plate
23
24 printf("\n The thickness of copper nedded to reduce
      the intensity of the radiation in cm is =%f",x)
```

Scilab code Exa 11.6 P11 6

```
1
2 //Ex11_6
3
4 clc;
5
6 //Given:
7
8 // Relative biological effectiveness(RBE)
9 a7=10;// for alpha partical
10 a6=1;//for gamma radiations
11 tn=2.5;// for thermal neutrons
12 g=1;// for gamma radiation
13 rd=0.6;//radiation dose in gray
```

```
14 //Formulas
15 //1.The Rontgen equivalent mammal (REM)=RBE*rads
16 //2.The sievert is the SI unit for REM= RBE*grays
17 //3. 1 gray(Gy)=100 rads
18
19 //Solution:
20
21 // part (a) alpha particles
22 a1=a7*rd// biological efective dose in Sv
23 a2=a1*100;// biological efective dose in rem
24 printf("\n The biological efective dose for alpha
      particles in Sv is = %f",a1)
25 printf("\n The biological efective dose for alpha
      particles in rem is = %f",a2)
26
27 // part (b) thermal neutrons
28 tn1=tn*rd// biological efective dose in Sv
29 tn2=tn1*100;// biological efective dose in rem
30 printf("\n \n The biological efective dose for
      thermal neutrons in Sv is = %f",tn1)
31 printf("\n The biological efective dose for thermal
      neutrons in rem is = %f",tn2)
32
33 // part (c) gamma particles
34 g1=a6*rd// biological efective dose in Sv
35 g2=g1*100;// biological efective dose in rem
36 printf("\n \n The biological efective dose for gamma
       particles in Sv is = %f",g1)
37 printf("\n The biological efective dose for gamma
      particles in rem is = %f",g2)
```

Scilab code Exa 11.7 P11 7

```
1
2 //Ex11_7
```

```
3
4 clc;
5
6 //Given:
7 density1=11.35;// density of copper
8 l=6.022*10^23;// avogadro constant
9 ue=0.211;// electron absorption coefficent in barn
     per electron
10 // 1 b=10^(-24) cm^2
11
12 //solution:
13
14 uPb=ue*82;//atomic absorbtion coefficient in b/atom
15 umPb=(6.022*10^23*uPb*10^-24)/207.2; // mass
     absorbtion coefficient in cm^2/g
16 ulPb=umPb*density1;// linear absorption coefficient
     in cm^-1
17
18 // we know that, i2=i1*exp(ulCu*x)
19 // Case (i) from 0.1 Gy/min to 3.1 mGy/h
20 i1=6;// in Gy/h
21 i2=3.1*10^-3;//in Gy/h
22 x=log(i1/i2)/(ulPb);// thickness of the lead plate
23 printf("\n The thickness of lead nedded to reduce
     the intensity of the radiation in cm is =%f",x)
24
25 // Case (ii) from 100 Gy/min to 0.1 mGy/h
26 j1=6000;// in Gy/h
27 j2=0.1*10^-3;// in Gy/h
28 y=log(j1/j2)/(ulPb);// thickness of the lead plate
29 printf("\n \n The thickness of lead nedded to reduce
     the intensity of the radiation in cm is =%f",y)
30
31 // Case (iii) half thickness
32 z=(0.693)/ulPb;// thickness of the lead plate
33 printf("\n \n The thickness of lead nedded to reduce
     the intensity of the radiation in cm is =%f",z)
```

Scilab code Exa 11.8 P11 8

```
1 //Ex11_8
2
3 clc;
4
5 // To find:
6
7 //(a)Z/A value for Carbontetrachloride
8 //(b)Z/A value for acetic acid
9 //(c)Z/A value for Cyclohexane
10
11 //Formula:
12 //(Z/A) for  compound = (summation of Z of all the
     atoms)/ molecular weight of compound
13
14 //solution:
15
16 // Part (a) CCl4
17
18 z1=(6+4*17)/154;// Z/A value for Carbontetrachloride
19 z2=(2*6+4*1+2*8)/60;// Z/A value for acetic acid
20 z3=(6*6+12*1)/84;// Z/A value for Cyclohexane
21
22 printf("\n The Z/A value for Carbontetrachloride is
     = %f",z1)
23 printf("\n \n The Z/A value for acetic acid is = %f"
     ,z2)
24 printf("\n \n The Z/A value for Cyclohexane is = %f"
     ,z3)
```

Scilab code Exa 11.9 P11 9

```
1  //Ex11_9
2
3  clc;
4  //Given:
5  dose1=2.15// in Gy/min
6  // Z values
7  Na=11;
8  I=53;
9  O=8;
10 // A values
11 mNa=23;
12 mI=127;
13 mO=16;
14 z2=0.553;//Z/A for fricke solution
15
16 // Solution:
17 z1=(11+53+8*4)/(127+23+16*4);// Z/A value for sodium
       periodate(Z/A NaIO4)
18
19 // Formula : D(NaIo4)*(Z/A Fricke)=D(Fricke)*(Z/A
     NaIO4)
20
21 dose2=(dose1*z1)/z2;// in Gy/min
22 // for 3 hours
23
24 Dose=dose2*180;// in Gy
25 printf("The dose absorbed by sodium periodate in 3 h
       is = %f Gy",Dose)
26
27
28 // Note: There is correction in the value of (Z/A
     NaIO4) calculated in the book. The actual value
     comes out to be 0.44859
```

Scilab code Exa 11.10 P11 10

```
1  //Ex11_10
2
3  clc;
4  //Given:
5  dose=4.06// in Gy/min
6  z=0.553;//Z/A for fricke solution
7
8
9  // Formula : D(NaIo4)*(Z/A Fricke)=D(Fricke)*(Z/A
       NaIO4)
10
11 // Solution:
12
13 // Part(a) Chloroform
14 z1=58/119.5;// Z/A value for Chloroform
15 dose1=dose*z1/z;
16 Dose1=dose1*360;// for 6 hours // in Gy
17 printf("\n The dose absorbed by sodium periodate in
       6 h is = %f Gy",Dose1)
18 // Part(b) Bromoform
19 z2=112/253;// Z/A value for Bromoform
20 dose2=dose*z2/z;
21 Dose2=dose2*360;// for 6 hours // in Gy
22 printf("\n \n The dose absorbed by sodium periodate
       in 6 h is = %f Gy",Dose2)
23 // Part(c) Iodoform
24 z3=166/394;// Z/A value for Iodoform
25 dose3=dose*z3/z;
26 Dose3=dose3*360;// for 6 hours // in Gy
27 printf("\n \n The dose absorbed by sodium periodate
       in 6 h is = %f Gy",Dose3)
```

Scilab code Exa 11.11 P11 11

```
1
```

```
2 //Ex11_11
3
4 clc;
5
6 // To find:
7 //Fraction of the energy absorbed by ethanol
8
9 //Formula:
10 //(Z/A) for  compound = (summation of Z of all the
     atoms)/ molecular weight of compound
11
12 z1=26/46;// Z/A value for ethanl
13 z2=32/60;// Z/A value for acetic acid
14 Deth=z1/(z1+z2);
15 // Note that the dose absorbed by each component is
     proportional to its Z/A in the total
16 printf("The fraction of the energy absorbed by
     ethanol = %f",Deth)
```

Scilab code Exa 11.12 P11 12

```
1 // Ex11_12
2
3 clc;
4 //Given:
5 density1=1.48;// for chloroform
6 density2=1.024;// for fricke solution
7 mole=30*10^-6;// moles of HCl
8 l=6.023*10^23;// avogadro constant
9 e=2174;//extension coefficient
10 OD=0.5633;
11 d=1;// cell path in cm
12 // G(Fe+3)=15.5 ions/100 eV
13 // Solution:
14
```

```
15 //HCl produced
16 m1=mole*l;
17 conc=OD*d/e;// in moles/l
18 conc1=conc*l;// molecules in 100 min
19
20 //This implies amount (conc1) of molecules/l in 10
      min for CHCl3 solution will be
21 conc2=conc1/10;
22 // energy that would be absorbed by frickes solution
       to produce conc1 amount of molecules
23
24 e1=conc2*100/15.5;// eV/l
25 e2=e1/100;// eV per 10 ml
26
27 // we know that energy absorbed is proportional to
      its density
28
29 e3=e2*density1/density2;// in eV
30
31 //G(HCl)
32 g=m1*100/e3;
33
34 printf("The value of G(HCL) in the radiolysis of
      CHCl3 is = %f",g)
```