CHAPTER 6

Iodide Ion: Design and Development of Computer based Measurement System
Section 6.1

HARDWARE DEVELOPMENT

Iodine was one of the first minerals to be recognized as vital for good health. It plays an important role in human life. It is the chief source present in thyroid glands which plays an important role in the secretion of thyroxine hormone. In the present work, a computer based system for measurement of iodide ion is designed and constructed. It works on the principle of an electrochemical cell, in which iodide ion sensitive electrode and a silver/silver chloride electrode is used as the working and reference electrodes. The potential developed in the solution is directly proportional to the concentration of the iodide ion in the solution. The emf produced is of the order of a few millivolts and it is generally of the order of 59.16 millivolts/decade at 25 °C. The potential of the iodide ion sensitive electrode is temperature dependent of the solution which is to be compensated.

The emf generated in the electrochemical cell is given to a high input impedance amplifier and the analog output of the amplifier is converted into digital form using an analog to digital converter. The digital information corresponding to concentration of iodide ion is stored and displayed with the help of a computer using appropriate interfacing devices. The necessary software to operate the system is developed in C language. The block diagram of the system is shown in Figure 6.1.

The system consists of the following functional blocks.

1. Iodide Ion Sensitive Electrode
2. Reference Electrode
3. Signal conditioner
4. Temperature sensing unit
5. Data acquisition system
6. Analog multiplexer
7. I/O card
8. Personal computer
9. Power supply unit
Figure 6.1 Block diagram of computer based system for Measurement of Iodide Ion

DAS: Data Acquisition System
DIOT: Digital Input Output Timer Card

Electrolyte

Reference Electrode

Temperature Sensor

Signal Conditioner

Power Supply

ADC

Mux

Analog

Signal Conditioner

Personal Computer
IODIDE ION SENSITIVE ELECTRODE

The iodide ion selective electrode used in the present study is made of a solid-state Crystal membrane which is sensitive for the detection of iodide ions in aqueous solutions and is suitable for both field and laboratory applications \(^3\). In the present study an iodide ion sensitive electrode is used as working electrode. The construction of the electrode is shown in Figure 6.2.

When the electrode is immersed in a solution containing iodide ions, the external ions diffuse through the membrane until equilibrium is reached between the external and internal concentrations. Thus, a potential difference is developed inside the membrane which is proportional to the concentration of the iodide ions. The potential of the electrode is measured against a standard reference electrode with a high impedance millivolt meter or digital measuring system which measures the potential difference accurately.

The potential developed across the ion selective membrane is directly proportional to the ion activity revealed by the Nernst equation\(^4,5\) discussed earlier and the slope of the electrode can be calculated by plotting a graph between the standard solutions of concentrations \(C_1\) and \(C_2\) versus potential developed in mV of the standard solutions which is shown in Figure 6.3.

In the present study the iodide ion sensitive electrode supplied by the pH products company, Hyderabad is used. It possesses the following specifications\(^6\).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring range</td>
<td>(10^{-1}) M to (10^{-6}) M (12700 – 0.127 ppm)</td>
</tr>
<tr>
<td>pH Range</td>
<td>3 – 12 pH</td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>0 – 80 °C</td>
</tr>
<tr>
<td>Slope range</td>
<td>-53 to -60 mV</td>
</tr>
</tbody>
</table>
Figure 6.2  Iodide Ion Selective Electrode
Iodide Ion Selective Membrane
Internal Filling Solution
Polymer body
Plastic Holder
To BNC Connector
Iodide Ion on Selective Membrane
Figure 6.3 Output Characteristics of Iodide Ion Selective Electrode
REFERENCE ELECTRODE
A stable reference voltage should be included in the circuit which acts as half-cell in the electrochemical cell to measure the change in potential difference across the iodide ion selective membrane as the ionic concentration changes. A stable reference voltage should be included in the circuit which acts as half-cell in the electrochemical cell. In the present system a double junction silver / silver chloride electrode is used as reference electrode\textsuperscript{7,8} which is shown in the Figure 5.4 in chapter 5.

The other functional blocks of the iodide ion measuring system are described in chapter 2. The schematic diagram of computer based system for measurement of iodide ion is shown in Figure 6.4.
Figure 6.4 Schematic Diagram of Computer based System for Measurement of Iodide Ion
Section 6.2
SOFTWARE DEVELOPMENT

The main role of the software in the present study is to govern the following activities.

1. To make the data acquisition system to convert the analog signal of the iodide ion sensitive electrode, temperature sensor output into corresponding digital information for data processing to personal computer.
2. To measure the temperature of any solution at an accuracy of ± 0.5°C.
3. To calibrate the iodide ion sensitive electrode using standard solutions by means of software to find the slope of the iodide ion sensitive electrode and to store the slope value.
4. To make the different functional units of system work in a systematic and sequential manner.
5. To compute, display and storage of iodide ion concentration and temperature values.
6. To indicate the hardware defects if any.

The necessary software in the present study is developed in C language to implement these tasks for effective functioning of the system.

SOFTWARE ROUTINES

The software program developed in the present study is divided into five parts using functions. Each routine is described below.

Hardware Testing

In the present study, a sub program is developed to test the hardware of the system which is used to test the DIOT card and analog to digital converter of the system. The details of the program are discussed in chapter 2.

Iodide ion measurement routine

1. Initialize the I/O card
2. Select the temperature channel by sending 00H data to Port C of 8255 (Use PC0, PC1&PC2).
3. Read the temperature signal from LM335 through ADC and store the value.
4. Select the iodide signal channel by sending 01H data to Port C of 8255 (Use PC0, PC1&PC2)
5. Read the iodide signal from the iodide ion sensitive electrode through ADC and store the value.
6. Compute the temperature and iodide values of the solution in terms of °C and M/ppm units respectively.
7. Store and display the temperature and iodide ion concentration of the solution
8. Repeat the steps from 2 to 8. The flow chart diagram for iodide ion measurement is shown in Figure 6.5.

Temperature measurement routine
The measurement of temperature for compensation of temperature error in the electrochemical cell is discussed earlier in chapter 2 at software routines section.

Calibration of the system routine
1. Prepare four concentrations of standard solutions (KI) of 0.1M, 0.01M, 0.001M & 0.0001M concentrations.
2. Dip the electrodes in 0.0001M standard KI solution and read the corresponding voltage developed in the cell.
3. Dip the electrodes in 0.001M standard KI solution and read the corresponding voltage developed in the cell and calculate the slope of the electrode for the first two solutions.
4. Dip the electrodes in 0.01M standard KI solution and read the corresponding voltage developed in the cell and calculate the slope of the electrode for the second and third solutions.
5. Finally dip the electrodes in 0.1M standard KI solution and read the corresponding voltage developed in the cell and calculate the slope of the electrode for the third and fourth solutions.
6. Compute and store the average slope of the electrode.

The flowchart for the calibration of the system is shown in Figure 6.6.
Figure 6.5 Flow Chart Diagram for Iodide Ion Measurement
Figure 6.6  Flow Chart Diagram for Calibration of the System
Quit routine

Press key No. 5 on the keyboard to quit from the program. The overall flow chart of the system is presented in Figure 6.7.

The detailed software program of the present system developed in C language is as follows.
Figure 6.7: Overall Flow Chart Diagram for Iodide Ion Measuring System

1. Hardware Testing
   - Tests the DS18B20 and ADC Module

2. Iodide
   - Measures the iodide ion concentration and stores the values

3. Temperature
   - Reads temperature from LM35 sensor and displays the temperature in °C

4. Calibration
   - Calibrates the system by using known standard solutions and stores the slope of the electrode

5. Quit
   - Comes out of the program execution

START

STOP

Return to Main Menu
PROGRAM IN DETAIL

/* Software Program for Computer Based System for Measurement of Iodide Ion */

#include<stdio.h>
#include<conio.h>
#include<dos.h>
#include<math.h>
#include<stdlib.h>
#include<graphics.h>
#define cl 0.01
#define c2 0.001
#define c3 0.0001
#define c4 0.00001

float adc_value,t;
int pa = Oxdfa0, pb = Oxdfal, pc = 0xdfa2, cr = 0xdfa3, cw = 0x92;
float clvol,slope,cone;
FILE *slp,*res;

//MAIN PROGRAM

void main()
{
    int opt;
    outportb(cr,cw);
    clrscr();
    again: opt=menu();
        if(opt==1)
        {
            system("hardtest.exe");
            goto again;
        }
        else if(opt==2)
        {
            iod();
            goto again;
        }
        else if(opt==3)
        {
            temperature();
            goto again;
        }
        else if(opt==4)
        {
            calibrate();
        }
goto again;
}
else if(opt==5)
{
quit( );
}
else
{

goto again;
}
}

// SUB ROUTINES //

// MENU SUBROUTINE //

int menu( )
{
int opt;
clrscr( );
gotoxy(20,3);
printf("COMPUTER BASED IODIDE ION MEASUREMENT");
gotoxy(23,6);
printf("1. ANALOG TO DIGITAL CONVERTER TEST");
gotoxy(23,7);
printf("2. IODIDE ION MEASUREMENT");
gotoxy(23,8);
printf("3. TEMPERATURE MEASUREMENT");
gotoxy(23,9);
printf("4. CALIBRATION OF THE SYSTEM");
gotoxy(23,10);
printf("5. QUIT");
gotoxy(23,15);
printf("SELECT YOUR CHOICE? = ");
scanf("%d",&opt);
return(opt);
}

// IODIDE ION MEASUREMENT ROUTINE

iod( )
{
float samp_vol,delta;
float ppm;
double frac,anlog;
clear: clrscr( );
gotoxy(31,3);
printf("IODIDE ION MEASUREMENT");
gotoxy(20,4);
printf("PLACE THE ELECTRODES IN THE SAMPLE SOLUTION");
do
{
    temp( );
    outportb(pc,0x00);  // Iodide channel
    delay(500);
    adc( );  // Cx = C2 * antilog(Δ/S)
    adc( );
    samp_vol = adc_value * 1000.0;  // Δ = delta = Ex - high E
    slp = fopen("iod71352.dat","r");
    fscanf(slp,"%f %f",&slope,&cl_vol);
    delta = samp_vol - cl_vol;
    fclose(slp);
    frac = delta/slope;
    anlog = pow(10,frac);
    conc = (cl * anlog) - (0.0002 * t);
    ppm = conc * 127000;
    if (conc > 1)
        goto clear;
    res = fopen("iodres.dat","w");
    fprintf(res,"Iconc : %f ppm : %f",conc,ppm);
    fclose(res);
    gotoxy(20,7);
    printf("The Iodide ion Conc. : %.7f",conc);
    gotoxy(20,8);
    printf("The Iodide ion Conc.in ppm : %.3f",ppm);
    gotoxy(20,9);
    printf("Temperature in Degree celcius : %.2f",t);
    gotoxy(20,10);
    printf("The Slope of the Electrode : %.2f",slope);
    gotoxy(20,13);
    printf("Press any key to stop");
}
while(!kbhit( ));
getch( );
return;

// TEMPERATURE MEASUREMENT SUBROUTINE

temperature( )
{
c1rsr( );
do
{
gotoxy(23,5);
Chapter 6

printf("TEMPERATURE MEASUREMENT");
temp();
gotoxy(20,8);
printf("Temperature in Degree celcius : %3.2f",t);
gotoxy(20,10);
printf("Press any key to stop");
}
while(!kbhit( ));
getch( );
return;

// CALIBRATION OF THE SYSTEM

calibrate( )
{
float c2_vol,c3_vol,c4_vol;
float s1,s2,s3,dif_1,dif_2,dif_3;
c1rsr( );
do
{

gotoxy(27,5);
printf("CALIBRATION OF THE SYSTEM ");
gotoxy(14,6);
printf("FOR CALIBRATION PREPARE 4 STANDARDS OF KI SOLUTIONS");
gotoxy(18,7);
printf("OF CONCENTRATIONS 0.01M,0.001M,0.0001 & 0.00001M ");
gotoxy(12,8);
printf("DIP THE ELECTRODES IN 0.00001M CONCENTRATION KI SOLUTION");
}
while(!kbhit( ));
getch( );
c1rsr( );
do
{

gotoxy(20,6);
printf("DIP THE ELECTRODES IN 0.00001M CONCENTRATION KI SOLUTION");
temp( );
outportb(pc,0x00); //Iodide channel
delay(500);
adc( );
adc( );
c4_vol = adc_value * 1000.0;
gotoxy(20,12);
printf("The voltage developed in 0.00001 M KI SOLN : %3.2f",c4_vol);
gotoxy(20,13);
printf("Temperature in Degree celcius : %3.2f", t);
gotoxy(20, 15);
printf("Press any key to continue...");
}
while (!kbhit ());
getch ();
c1scre ( );
do {
  gotoxy(20, 4);
  printf("DIP THE ELECTRODES IN 0.0001M CONCENTRATION KI SOLUTION");
gotoxy(20, 14);
  printf("Press any key to continue...");
}
while (!kbhit ());
getch ();
c1scre ( );
do {
  temp ( );
  outportb (pc, 0x00); // Iodide channel
  delay (500);
  adc ( );
  adc ( );
  c3_vol = adc_value * 1000.0;
  dif_1 = c4_vol - c3_vol;
  s1 = dif_1/(log10(c4) - log10(c3));
gotoxy(20, 3);
  printf("DIP THE ELECTRODES IN 0.0001M CONCENTRATION KI SOLUTION");
gotoxy(20, 7);
  printf("Voltage developed in 0.0001 M KI SOLN : %3.2f", c3_vol);
gotoxy(20, 8);
  printf("Temperature in Degree celcius : %3.2f", t);
gotoxy(20, 9);
  printf("SLOPE OF THE ELECTRODE : %2.2f", s1);
gotoxy(20, 13);
  printf("Press any key to continue...");
}
while (!kbhit ());
getch ();
c1scre ( );
do {
  gotoxy(20, 4);
  printf("DIP THE ELECTRODES IN 0.001M CONCENTRATION KI SOLUTION");
gotoxy(20, 14);
printf("Press any key to continue... ");
}
while(!kbhit( ));
getch( );
c1rsr( );
do {
  temp( );
  outportb(pc,0x00);  // Iodide channel
  delay(500);
  adc( );
  adc( );
c2_vol = adc_value * 1000.0;
d2 = c3_vol - c2_vol;
s2 = d2/(log10(c3) - log10(c2));
gotoxy(20,3);
  printf("DIP THE ELECTRODES IN 0.001M CONCENTRATION KI SOLUTION");
gotoxy(20,7);
  printf("Voltage developed in 0.001 M KI SOLN : %3.2f",c2_vol);
gotoxy(20,8);
  printf("Temperature in Degree celcius : %3.2f",t);
gotoxy(20,9);
  printf("SLOPE OF THE ELECTRODE : %2.2f",s2);
gotoxy(20,13);
  printf("Press any key to continue ...");
}
while(!kbhit( ));
getch( );
c1rsr( );
do {
  gotoxy(20,4);
  printf("DIP THE ELECTRODES IN 0.01M CONCENTRATION KI SOLUTION");
gotoxy(20,14);
  printf("Press any key to continue ...");
}
while(!kbhit( ));
getch( );
c1rsr( );
do {
  temp( );
  outportb(pc,0x00);  // Iodide channel
  delay(500);
  adc( );
  adc( );
c1_vol = adc_value * 1000.0;
\[ \text{dif}_3 = \text{c2}_\text{vol} - \text{c1}_\text{vol}; \]
\[ s3 = \frac{\text{dif}_3}{(\log_{10}(c2) - \log_{10}(c1))}; \]
\[ \text{slope} = \frac{(s1 + s2 + s3)/3.0}{(0.0002 * t)}; \]

gotoxy(20,3);
printf("DIP THE ELECTRODES IN 0.01M CONCENTRATION KI SOLUTION");
gotoxy(20,7);
printf("Voltage developed in 0.01 M KI SOLN : \%3.2f",c1_vol);
gotoxy(20,8);
printf("Temperature in Degree celcius : \%3.2f",t);
gotoxy(20,9);
printf("Slope of the Electrode : \%2.2f",s3);
gotoxy(20,10);
printf("AVERAGE SLOPE OF THE ELECTRODE : \%2.2f",slope);
gotoxy(20,15);
printf("Press any key to continue...");
slp = fopen("iod71352.dat","w");
fprintf(slp,"%f %fslope,c1_vol);
fclose(slp);
}
while(!kbhit ());
getch();
return(slope);
}
// QUIT ROUTINE
quit ( )
{
    return;
}
// temp function

temp ( )
{
    outportb(pc,0x01);  //temperature channel
delay(500);
adc ( );
adc ( );
t = ((adc_value) * 100);
return(t);
}
// adc function
adc( ) function program is presented in chapter 3.

*****
Chapter 6

Section 6.3
CALIBRATION AND MEASUREMENT PROCEDURES

The individual blocks of the computer based system for measurement of iodide ion are designed and constructed. The necessary software is developed in C language. These details are already discussed earlier.

Before using the system, the electrodes must be calibrated by measuring a series of known standard solutions, made by serial dilution of the 0.1M KI standard solution. In the present study, the system is calibrated at four concentrations of standard KI solutions – 0.01M, 0.001M, 0.0001M and 0.00001M.

Preparation of the standard solutions:
To prepare the standard solutions, primarily, make a stock solution of 0.01M KI which is prepared by dissolving 58.44 milli grams of iodide chloride salt in 100 ml of distilled water.

To prepare 0.001M KI solution take 10 ml of 0.01M KI solution and dilute it to 100 ml with distilled water. For 0.0001M KI solution take 10 ml of 0.001M KI solution and dilute it to 100 ml with distilled water. Similarly for 0.00001M KI solution take 10 ml of 0.0001M KI solution and dilute it to 100 ml with distilled water. 2 ml of 2.5 Molar KI buffer solution (ISAB) should be added to each 100 ml standard and mix thoroughly to compensate for different activity coefficients between samples and standards. The standard solutions are prepared in the laboratory in accordance with the accepted principles of analytical chemistry.

After preparing the standard solutions, run the software program of the system for calibration. When the execution of the program starts, a user menu is displayed on the CRT screen of the computer as shown below.
Main Menu
1. Hardware Testing
2. Iodide Measurement
3. Temperature Measurement
4. Calibration of the system
5. Quit

Select the option ‘4’ for calibration of the system by pressing key number 4 on the keyboard and press ‘Enter key’. Now the system is ready to calibrate the system.

The calibration menu itself guides the user to calibrate the system which is shown below (which appears on the Monitor of the PC).

CALIBRATION OF THE SYSTEM
FOR CALIBRATION PREPARE 4 STANDARDS OF KI SOLUTIONS OF CONCENTRATIONS 0.1M, 0.01M, 0.001M & 0.0001M
(Rinse the electrodes with distilled water thoroughly and blot dry with tissue paper before dipping the electrodes in the solutions every time)

DIP THE ELECTRODES IN 0.0001M CONCENTRATION KI SOLUTION
After a stable reading press any key on the keyboard to continue to next step.

DIP THE ELECTRODES IN 0.001M KI STANDARD SOLUTION
After stable reading we can see the slope of the electrode in milli volts/decade for the first two standard solutions. Press any key on the keyboard to continue to next step.

DIP THE ELECTRODES IN 0.01M KI STANDARD SOLUTION
After stable reading we can see the slope of the electrode in milli volts/decade for the second and third standard solutions. Press any key on the keyboard to continue to next step.
DIP THE ELECTRODES IN 0.1M KI STANDARD SOLUTION

The average slope of the iodide ion sensitive electrode is computed and displayed on the screen. And it automatically switches to main menu after pressing the enter key on the keyboard.

Now the calibration of the system is completed and the system is ready to measure the iodide ion concentration of the sample. The slope of the electrode tells the sensitivity and linearity of the iodide ion sensitive electrode.

After making the appropriate adjustments both in the hardware and software and also following the calibration procedure as mentioned earlier, the instrument is tested with the standard solutions of iodide. The outputs of the iodide ion measuring system are presented in Figure 6.8 to Figure 6.12. The results of measurements are presented in Table 6.1. The measurements made are compared with an Ion Analyzer of Elico Make (Model No. LI126) and the results are presented in the same table. The results of the present study are in good agreement with those obtained from the Ion analyzer. The system is quite successful in the measurement of iodide ion. The results of some other samples are discussed in chapter 9.
### TABLE 6.1
IODIDE ION MEASUREMENT IN STANDARD SOLUTIONS

<table>
<thead>
<tr>
<th>Molarity (M)</th>
<th>Standard values ppm</th>
<th>Present study M/ppm</th>
<th>Ion Analyzer ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1M (KI)</td>
<td>12700.00</td>
<td>0.1000012/12702.30</td>
<td>12702.00</td>
</tr>
<tr>
<td>0.01M (KI)</td>
<td>1270.00</td>
<td>0.0100000/1270.00</td>
<td>1271.05</td>
</tr>
<tr>
<td>0.001M (KI)</td>
<td>127.00</td>
<td>0.0010390/128.30</td>
<td>125.02</td>
</tr>
<tr>
<td>0.0001M (KI)</td>
<td>12.79</td>
<td>0.0001090/13.80</td>
<td>11.99</td>
</tr>
<tr>
<td>0.00001M(KI)</td>
<td>1.27</td>
<td>0.0000101/1.31</td>
<td>1.31</td>
</tr>
<tr>
<td>0.000001M(KI)</td>
<td>0.12</td>
<td>0.0000010/0.12</td>
<td>0.14</td>
</tr>
</tbody>
</table>
**COMPUTER BASED IODIDE ION MEASUREMENT**

1. HARDWARE TESTING
2. IODIDE ION MEASUREMENT
3. TEMPERATURE MEASUREMENT
4. CALIBRATION OF THE SYSTEM
5. QUIT

SELECT YOUR CHOICE? : 1

Figure 6.8 : Main menu of Iodide Ion measurement system
HARDWARE TESTING

1. TESTING OF DIGITAL INPUT OUTPUT CARD
2. TESTING OF DATA ACQUISITION SYSTEM
3. QUIT

SELECT YOUR CHOICE? : 1

Figure 6.9 : Main menu of hardware testing of the system

TESTING OF DIGITAL INPUT OUTPUT CARD

Connect the test module to the I/O card connector

Press any key when ready

Observe the test module for ON and OFF of the LED's

Press any key to stop

Figure 6.9a : Digital Input Output Timer card testing
TESTING OF DATA ACQUISITION SYSTEM

Apply Known DC voltage (+/-1.5V) to channel 0 or 1
Enter the channel No. : 1
The Voltage in V : 0.225
Press any key to stop

Figure 6.9b : Data acquisition system testing

IODIDE ION MEASUREMENT
PLACE THE ELECTRODES IN THE SAMPLE SOLUTION

The Iodide ion Conc. in M : 0.0010390
The Iodide ion Conc.in ppm : 128.30
Temperature in degree celcius : 28.16
The Slope of the Electrode : -58.14 mV/decade

Press any key to stop

Figure 6.10 : Iodide ion measurement
TEMPERATURE MEASUREMENT

Temperature in degree celcius : 28.15

Press any key to stop

Figure 6.11 : Temperature measurement

CALIBRATION OF THE SYSTEM

FOR CALIBRATION PREPARE 4 STANDARDS OF KI SOLUTIONS OF CONCENTRATIONS 0.01M, 0.001M, 0.0001 & 0.00001M

DIP THE ELECTRODES IN 0.00001M CONCENTRATION KI SOLUTION

Press any key to continue...

Figure 6.12 : Calibration of Iodide ion Measuring System
DIP THE ELECTRODES IN 0.00001M CONCENTRATION KI SOLUTION

The voltage developed in 0.00001 M KI SOLN : -38.8 mV
Temperature in degree celcius : 29.20

Press any key to continue...

Figure 6.12a : Voltage developed in 0.0001M KI Solution

DIP THE ELECTRODES IN 0.0001M CONCENTRATION KI SOLUTION

The voltage developed in 0.0001 M KI SOLN : 20.50 mV
Temperature in degree celcius : 29.21
SLOPE OF THE ELECTRODE : 59.30 mV

Press any key to continue...

Figure 6.12b : Voltage developed in 0.001M KI Solution
DIP THE ELECTRODES IN 0.001M CONCENTRATION KI SOLUTION

The voltage developed in 0.001 M KI SOLN : 78.00 mV
Temperature in degree celcius : 29.21
SLOPE OF THE ELECTRODE : 57.50 mV

Press any key to continue...

Figure 6.12c : Voltage developed in 0.01M KI Solution

DIP THE ELECTRODES IN 0.01M CONCENTRATION KI SOLUTION

The voltage developed in 0.01 M KI SOLN : 136.20 mV
Temperature in degree celcius : 29.20
SLOPE OF THE ELECTRODE : 58.20 mV
AVERAGE SLOPE OF THE ELECTRODE : 58.33 mV

Press any key to continue...

Figure 6.12d : Voltage developed in 0.1M KI Solution
7. Material on Ion-selective Electrodes prepared by Wojciech Wroblewski in the website, with address www.ch.pv.cdo.pl/~dybko/csrg/tutorials/ise/ion selective electrodes.htm