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Calculations of mathematical equations of state through CPP programming

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Abstract:

This paper contains the program designed in C & Cpp to solve the different equations of state which are Vander Waal's equation of state, Redlich-Kwong, Soave-Redlich and Peng Robinson particularly for gas condensates as these are the complex reservoirs so, they need different methods for their implementation. With the help of the codes written in this paper, different parameters like repulsion factor, attraction factor, compressibility factor, etc. are being computed and the console-based calculations are mentioned. With the help of these code the complicated calculations are made easy as the researcher/scholar has to put only the values and the appropriate values without human error can be obtained.

Introduction:

The equation of state (EOS) is the analytical formula that links pressure (p), temperature (T), and volume (V) (V). A detailed description of the PVT relationship for hydrocarbon fluids is necessary in order to ascertain the volumetric and phase behaviour of petroleum reservoir fluids and to forecast the performance of surface separation facilities. EOS can characterise the volumetric and phase behaviour of pure substances and mixtures using critical features (Pc, Tc), an acentric factor (w) for each component, and the molecular weight of each component. Additionally, it is used to determine miscibility, address multiphase behaviour issues like low-temperature CO2 flooding, and produce black oil characteristics.

The simplest illustration of a state equation is the ideal gas equation. The following is how it can be mathematically expressed:

$$P = \frac{RT}{V}$$

Where P = system pressure, psia

T = system temperature, °R

R = gas constant, 10.73 psi-ft3/lb-mol = °R

V = volume, ft3/mol

Contrarily, the volumetric behaviour of actual hydrocarbon gases could only be described using this PVT relationship at pressures close to atmospheric pressure. The several kinds of equations of state are as follows:

1. Vander Waal's cubic Equation of state

Van der Waals, Cubic EOS can describe the liquid-condensation phenomena and the change from the gas to the liquid phase as the gas compresses. It can be mathematically stated in terms of volume as follows:

$$V^3 - \left(b + \frac{RT}{p}\right)V^2 - \left(\frac{a}{p}\right)V - \left(\frac{ab}{p}\right) = 0$$

The compressibility factor Z can be used to more directly express the aforementioned equation. This can be said in the following way:

$$Z^3 - (1 + B)Z^2 + AZ - AB = 0$$

Where A = $\frac{ap}{R^2T^2}$

B = $\frac{bp}{RT}$

1.1 Program for the Vander Waal's equation of state is as follows:

```
#include<iostream>
#include<math.h>
using namespace std;
int main()
{
//Expression for the Vander Waal's equation of state
// p=(RT/V-b)-(a/V^2)
cout<<"Now the calculation for 'a' begins"<<endl;
cout<<"Where 'a'=attraction parameter'<<endl;
///
double omega_a,R,Tc,Pc;
cout<<"Enter the value of Omega_a"<<endl;
cin>>Omega_a;
//
cout<<"Enter the value of R"<<endl;
cout<<"Where R= gas constant"<<endl;
cin>>R;
///
cout<<"Enter the value of Tc"<<endl;
cout<<"Where Tc = Critical temperature in Rankine"<<endl;
cin>>Tc;
///
cout<<"Enter the value of Pc"<<endl;
cout<<"Where Pc = Critical pressure in Psia"<<endl;
cin>>Pc;
/////
double a;
a = (omega_a*R*R*Tc*Tc)/Pc;
cout<<"The value of 'a' comes out to be ="<<a<<endl;
////////
cout<<"Now the calculation for 'b' begins"<<endl;
cout<<"Where b = repulsion parameter"<<endl;
double b, Omega_b;
/////
cout<<"Enter the value of Omega_b"<<endl;
cin>>Omega_b;
///
b=(Omega_b*R*Tc)/Pc;
///
```

```
cout<<"The value of 'b' comes out to be = "<<b<<endl;
///
cout<<"Now the calculation for 'p' begins"<<endl;
double T,p;
double x;
cout<<"Enter the value of T"<<endl;
cout<<"Where T = System Temperature"<<endl;
cin>>T;
///
cout<<"Enter the value of P"<<endl;
cin>>p;
///
cout<<"After introducing the compressibility factor Z the equation comes out to be:"<<endl;
cout<<"Z^3-(1+B)Z^2+AZ-AB=0";
//////////////////////////////
/////////////////////

cout<<"Where A=ap/R^2*T^2"<<endl;
double A=(a*p)/(R*R*T*T);
cout<<"The value of A is="<<A<<endl;
/////////////////////

cout<<"B=bp/RT"<<endl;
double B=(b*p)/(R*T);
cout<<"The value of B is="<<B<<endl;
///
double x1,x2,x3,x4;
x2=-(1+B);
cout<<"The value of x2 is"<<x2<<endl;
//
x3=A;
cout<<"The value of x3 is"<<x3<<endl;
///
x4=-(A*B);
cout<<"The value of x4 is"<<x4<<endl;

//////////////////////////////
/////////////////////
double Z_gas,Z_liq;
double density_gas,density_liq;
double M_gas,M_liq;
cout<<"Enter the value of the molecular weight of gas"<<endl;
cin>>M_gas;
//cout<<"Enter the value of the compressibility factor"<<endl;
//cin>>Z;
cout<<"Now calculating the density"<<endl;
cout<<"Enter Z for vapour"<<endl;
cin>>Z_gas;
density_gas=(p*M_gas)/(Z_gas*R*T);
cout<<"The value of the density of gas is = "<<density_gas<<endl;
/////////////////
cout<<"Enter Z for liquid"<<endl;
cin>>Z_liq;
//
```

```
cout<<"Enter the value of the molecular weight of liquid "<<endl;
cin>>M_liq;
////
density_liq=(p*M_liq)/(Z_liq*R*T);
cout<<"The value of the density of liquid "<<density_liq;
/////////////////
//////////////



return 0;
}
```

```
C:\Users\vksk2\Desktop\407codes\vander waals.exe
Now the calculation for 'a' begins
Where 'a'=attraction parameter
Enter the value of Omega_a
0.421875
Enter the value of R
Where R=gas constant
10.73
Enter the value of Tc
Where Tc=Critical Temperature in Rankine
666
Enter the value of Pc
Where Pc=Critical pressure in Psia
616.3
The value of a comes out to be =34957.4
Now the calculation for 'b' begins
Where b=Repulsion Parameter
Enter the value of Omega_b
0.125
The value of 'b' comes out to be = 1.44941
Now the calculation for 'p' begins
Where p=System pressure in psia
Enter the value of T
Where T=System Temperature
560
Enter The value of p
185
After introducing the compressibility factor Z the equation comes out to be:
Z^3-(1+B)Z^2+AZ-AB=0Where A=ap/R^2*T^2
The value of A is=0.179117
B=bp/RT
The value of B is=0.0446247
The value of x2 is-1.04462
The value of x3 is0.179117
The value of x4 is-0.00799303
Enter the value of the molecular weight of gas
44
Now calculating the density
Enter Z for vapour
0.843506
The value of the density of gas is = 1.60601
Enter Z for liquid
```

```
The value of the density of gas is = 1.60601
Enter Z for liquid
0.075343
Enter the value of the molecular weight of liquid
44
The value of the density of liquid 17.9802
--------------------------------
Process exited after 84.53 seconds with return value 0
Press any key to continue . . .
```

```
 a*x^3+b*x^2+c*x+d:
a=1

b=-1.04462

c=0.179117

d=-0.00799303

A 3 Roots:
0.843506
0.075343
0.125772
```

2. **Roots of the equations are obtained from another code which is as follows:**

```
//// Z calculation
#include<stdio.h>
#include<conio.h>
#include<math.h>
int main()

{

double a,b,c,d,e,f,g,h,i,j,k,l,m,n,p,r,s,t,u,x1,x2,x3;

int w;
printf("\n a*x^3+b*x^2+c*x+d:\n");
printf("a=");
```

```
scanf("%lf", &a);
printf("\nb=");
scanf("%lf", &b);
printf("\nc=");
scanf("%lf", &c);
printf("\nd=");
scanf("%lf", &d);
e=2.7182818284590;
f=((3*c/a)-(b*b/(a*a)))/3; // ** bracketed (a*a)!
g=((2*b*b*b/(a*a*a))-(9*b*c/(a*a))+(27*d/a))/27; // ** brackets!
h=(g*g/4)+(f*f*f/27);
i=sqrt(((g*g/4)-h));
j=exp(log10(i)/log10(e)/3);
k=acos((-1)*(g/(2*i)));
l=j*(-1);
m=cos(k/3);
n=sqrt(3)*sin(k/3);
p=(b/3*a)*(-1);
r=(-1)*(g/2)+sqrt(h);
s=exp(log10(r)/log10(e)/3);
t=(-1)*(g/2)-sqrt(h);
u=exp(log10(t)/log10(e)/3);
if (h>0) w=1;
if (h<=0) w=3;
if ((f==0) && (g==0) && (h==0)) w=2;

switch (w){

case 1:
x1=(s+u)-(b/3*a);
x2=(-1)*(s+u)/2-(b/3*a);
x3=(s-u)*sqrt(3)/2;
printf("\nA 3 pont:\n%lf\n%lf +i*%lf\n%lf -i*%lf", x1, x2, x3, x2, x3);
break;

case 2:

x1=exp(log10(d/a)/log10(e)/3)*(-1);
printf("\n There is a line:\n%lf", x1);

break;

case 3:
x1=2*j*cos(k/3)-(b/3*a);
x2=l*(m+n)+p;
x3=l*(m-n)+p;
printf("\nA 3 Roots:\n%lf\n%lf\n%lf", x1, x2, x3);

break;
}
getch();
}
```

3. Redlich-Kwong equation of state

Redlich and Kwong created their equation of state in 1949. The Vander Waals attractive pressure term a/V2 was replaced by a generalised temperature dependency term. Take the following equation as an example:

$$p = \frac{RT}{V-b} - \frac{a}{V(V+b)\sqrt{T}}$$

where T is the system temperature in °R.
The aforementioned equation can be expressed as follows in terms of compressibility factor Z:

$$Z^3 - Z^2 + (A - B - B^2)Z - AB = 0$$

where A = $\frac{ap}{R^2T^{2.5}}$

B = $\frac{bp}{RT}$

By including the following mixing principles, Redlich - Kwong EOS is applied to mixes of liquid and gaseous hydrocarbons:

$a_m = \left[\sum_{i=1}^{n} x_i\sqrt{a_i}\right]^2$

$b_m = \sum_{i=1}^{n} x_i b_i$

where n = number of components in mixture

a_i= Redlich-Kwong a parameter for the i'th component

b_i = Redlich-Kwong b parameter for the i'th component

a_m = parameter a for mixture

b_m = parameter b for mixture

x_i = mole fraction of component i in the liquid phase

For gaseous mixtures, swap out xi for yi. Redlich-Kwong EOS produces a universal critical compressibility factor (Zc) of 0.333 for all substances. The essential gas compressibility for the majority of compounds ranges from 0.23 to 0.31.

3.1 Following is the code which is designed to solve the latter:

```
// Soave-Redlich-Kwong Equation of State and Its Modifications
#include<iostream>
#include<math.h>
using namespace std;
int main()
{
        // p=(RT/V-b)-(a*alpha*T)/(V(V+b)
                cout<<"Now calculating the reduced temperature"<<endl;
        double T,Tc,Tr;
        cout<<"Enter the value of temperature "<<endl;
        cin>>T;
        cout<<"Enter the value of critical temperature"<<endl;
        cin>>Tc;
```

```
        Tr=T/Tc;
        cout<<"The value of reduced temperature comes out to be = "<<Tr<<endl;

        cout<<"Now the calculations for alpha_T begins"<<endl;

        double  alpha_T,  m,w;
        cout<<"Enter the value of w"<<endl;
        cin>>w;

        m=0.480+1.574*w-0.176*w*w;
        cout<<"The value of m is ="<<m<<endl;

        // Tr=reduced temperature, T/Tc
        // w=acentric factor of the substance
        // T= system temperature, Rankine
         //alpha(T)=[1+m*(1-sqrt*Tr)]^2


        double x=sqrt(Tr);
        ////////////////////////////////////////
        double y= 1+m*(1-x);
        alpha_T=pow(y,2);
        ////////////////////////////////
        cout<<"The value of alpha comes out to be = "<<alpha_T<<endl;
//      |||||||||||||||||||||||||||||||||||||||||||||||||||||||| //
cout<<"Now calculations for ''a'' begins"<<endl;

        double Omega_a, R , Pc;
        double a;
        cout<<"Enter the value of R"<<endl;
        cin>>R;
        cout<<"Enter the value of Omega_a"<<endl;
        cin>>Omega_a;
        cout<<"Enter the value of Tc";
        cin>>Tc;
        cout<<"Enter the value of Pc"<<endl;
        cin>>Pc;


        a= (Omega_a*R*R*Tc*Tc)/Pc;
        cout<<"The value of a comes out to be = "<<a<<endl;
        ////////////////////////////////////////////////
        cout<<"Now the calculation for 'b' begins"<<endl;

        double Omega_b;
        double b;
        cout<<"Enter the value of Omega_b"<<endl;
        cin>>Omega_b;

        b=(Omega_b*R*Tc)/Pc;

        cout<<" the value of b"<<b<<endl;
        ////////////////////////////////////
        cout<<"Now after calculating all the parameters now we have to calculate 'p' "<<endl;
```

```
        //cout<<"Now enter the value of T"<<endl;

        double p,alpha_p;
//      cout<<"Enter the value of V"<<endl;
//
//      v= R*T/(V-b);
//      long k;
//      k=(a*alpha_p*T)/(V*(V+b));
//      p=(v-k);
        cout<<"Enter the value of p"<<endl;
        cin>>p;
        cout<<"Enter the value of alpha_p"<<endl;
        cin>>alpha_p;

        double A,B;
        A=(a*alpha_p*p)/(R*R*T*T);
        cout<<"The value of A is ="<<A<<endl;
        B=(b*p)/(R*T);
        cout<<"The value of B is "<<B<<endl;
        ////////////////////////
        ////////////////////
        cout<<"Now the new equation by introducing the compressibility factor Z, by replacing the molar volume V
in the equation with ZRT/p comes out to be"<<endl;
        cout<<"Z^3-Z^2+(A-B-B^2)Z-AB=0"<<endl;
        ////
        double x2,x3;
        x2=-1;
        cout<<"The value of x2 is"<<x2<<endl;
        ///
        x3=A-B-B*B;
        cout<<"The value of x3 is "<<x3<<endl;
        ///
        double x4;
        x4=-(A*B);
        cout<<"The value of x4 is"<<x4<<endl;
        //comp_eq=Z^3-Z^2+(A-B-(B*B))Z-(A*B);

        double density_gas,density_liq;
double M_gas,M_liq,Z_gas,Z_liq;
cout<<"Enter the value of the molecular weight of gas"<<endl;
cin>>M_gas;
cout<<"Enter the value of the compressibility factor of gas"<<endl;
cin>>Z_gas;
cout<<"Now calculating the density of gas"<<endl;
density_gas= p*M_gas/(Z_gas*R*T);
cout<<"The value of the density of gas is = "<<density_gas<<endl;
/////////////
//////////////
cout<<"Enter the value of the molecular weight of liquid"<<endl;
cin>>M_liq;
cout<<"Enter the value of the compressibility factor of liquid"<<endl;
cin>>Z_liq;
cout<<"Now calculating the density of liquid"<<endl;
density_liq= p*M_liq/(Z_liq*R*T);
```

```
cout<<"The value of the density of liquid is = "<<density_liq<<endl;
        return 0;



}
```

```
Now calculating the reduced temperature
Enter the value of temperature
560
Enter the value of critical temperature
666.01
The value of reduced temperature comes out to be = 0.840828
Now the calculations for alpha_T begins
Enter the value of w
0.1524
The value of m is =0.71579
The value of alpha comes out to be = 1.1224
Now calculations for ''a'' begins
Enter the value of R
10.73
Enter the value of Omega_a
0.42747
Enter the value of Tc666.01
Enter the value of Pc
616.3
The value of a comes out to be = 35422.1
Now the calculation for 'b' begins
Enter the value of Omega_b
0.08664
 the value of b1.00463
Now after calculating all the parameters now we have to calculate 'p'
Enter the value of p
185
Enter the value of alpha_p
1.1224
The value of A is =0.203713
The value of B is 0.0309308
Now the new equation by introducing the compressibility factor Z, by replacing the molar
Z^3-Z^2+(A-B-B^2)Z-AB=0
The value of x2 is-1
The value of x3 is 0.171825
The value of x4 is-0.00630099
Enter the value of the molecular weight of gas
44
Enter the value of the compressibility factor of gas
0.793456
```

```
Enter the value of the molecular weight of liquid
44
Enter the value of the compressibility factor of liquid
0.051081
Now calculating the density of liquid
The value of the density of liquid is = 26.5202

--------------------------------
Process exited after 87.58 seconds with return value 0
Press any key to continue . . .
```

```
 a*x^3+b*x^2+c*x+d:
a=1

b=-1

c=0.171825

d=-0.00630099

A 3 Roots:
0.793456
0.051081
0.155464
```

4. Soave-Redlich-Kwong equation of state:

The attractive pressure element of the Redlich-Kwong equation of state was modified by Soave in 1972 by changing the parameter an. The author has changed the wording "a/T0.5" to a more general "temperature dependent" term. Think about the following equation as an illustration:

$$p = \frac{RT}{V-b} - \frac{a\alpha}{V(V+b)}$$

where α = dimensional factor that becomes unity at T = Tc. Other than critical temperature α can be defined as:

$$\alpha = \left[1 + m\left(1 - \sqrt{T_r}\right)\right]^2$$

where m is correlated with acentric factor to give the following equation:

m = 0.480 + 1.574ω - 0.176ω^2

here, ω = acentric factor of a substance

T_r = reduced temperature given by T/ T_c.

SRK EOS can be written in terms of compressibility factor Z through the following equation:

$$Z^3 - Z^2 + (A - B - B^2)Z - AB = 0$$

Where A = $\frac{(a\alpha)p}{(RT)^2}$

B = $\frac{bp}{RT}$

Soave adopted the following mixing rules in order to use the above equation for hydrocarbon liquid and gaseous mixtures:

$$(a\alpha)_m = \sum i \sum j\left[x_i x_j \sqrt{a_i a_j \alpha_i \alpha_j}\left(1 - k_{ij}\right)\right]$$

$$b_m = \sum i[x_i b_i]$$

With A = $\frac{(a\alpha)_m p}{(RT)^2}$

B = $\frac{b_m p}{RT}$

In case of gaseous mixture, replace x_i with y_i

4.1 Following is the code to compute the SRK equation of state:

```
// Redlich-Kwong's equation of state

#include<iostream>
#include<math.h>
using namespace std;
int main()
{
// p=(RT/(V-b))-a/(V(V+b)sqrt(T));
///
cout<<"Now the calculation for 'a' begins"<<endl;
double Omega_a,R,Tc,Pc;
cout<<"Enter the value of Omega_a"<<endl;
cin>>Omega_a;
cout<<"Enter the value of R"<<endl;
cin>>R;
cout<<"Enter the value of Tc"<<endl;
```

```
cin>>Tc;
cout<<"Enter the value of Pc "<<endl;
cin>>Pc;
double x;
x=sqrt(Tc);
double a;
a=Omega_a*R*R*Tc*Tc*x/Pc;
cout<<"The value of a comes out to be = "<<a<<endl;
/////////////////
cout<<"Now the calculation of 'b begins"<<endl;
double Omega_b;
double b;
cout<<"Enter the value of Omega_b"<<endl;
cin>>Omega_b;
b=Omega_b*R*Tc/Pc;
cout<<"The value of Omega_b comes out to be "<<b<<endl;
///////////
cout<<"Now the calculation for 'p' begins"<<endl;
double p,V,T;
cout<<"Enter the value of V"<<endl;
cin>>V;
cout<<"Enter the value of temperature in Rankine"<<endl;
cin>>T;
///
double y=sqrt(T);
double h;
h=(a/(V*(V+b)*y));
double k;
k=R*T/(V-b);
p=k-h;
cout<<"Enter the value of 'p' "<<endl;
cin>>p;
///
cout<<"Now after introducing the Compressibility factor Z the equations rearranges like:"<<endl;
cout<<"Z^3-Z^2+(A-B-B^2)Z-AB=0"<<endl;
cout<<"Where A=ap/R^2*T^2.5"<<endl;
double A;
double kk=sqrt(T);
A=(a*p)/(R*R*T*T*kk);
cout<<"The value of A is ="<<A<<endl;
double B;
B=(b*p)/(R*T);
cout<<"The value of B is ="<<B<<endl;
///
double x2,x3,x4;
x2=-1;
cout<<"The value of x2 is"<<x2<<endl;
//
x3=A-B-B*B;
cout<<"The value of x3 is="<<x3<<endl;
///
x4=-(A*B);
cout<<"The value of x4 is="<<x4<<endl;
//
```

```
double density_gas,density_liq;
double M_gas,M_liq,Z_gas,Z_liq;

cout<<"Enter the value of the molecular weight of gas"<<endl;
cin>>M_gas;
cout<<"Enter the value of the compressibility factor of gas"<<endl;
cin>>Z_gas;
cout<<"Now calculating the density of gas"<<endl;
density_gas= p*M_gas/(Z_gas*R*T);
cout<<"The value of the density of gas is = "<<density_gas<<endl;
//////////////////////////
//////////////////////////
cout<<"Enter the value of the molecular weight of liquid"<<endl;
cin>>M_liq;
cout<<"Enter the value of the compressibility factor of liquid"<<endl;
cin>>Z_liq;
cout<<"Now calculating the density of gas"<<endl;
density_liq= p*M_liq/(Z_liq*R*T);
cout<<"The value of the density of liq is = "<<density_liq<<endl;
 return 0;
}

}
```

```
Now the calculation for 'a' begins
Enter the value of Omega_a
0.42747
Enter the value of R
10.73
Enter the value of Tc
666
Enter the value of Pc
616.3
The value of a comes out to be = 914110
Now the calculation of 'b begins
Enter the value of Omega_b
0.08664
The value of Omega_b comes out to be 1.00462
Now the calculation for 'p' begins
Enter the value of temperature in Rankine
560
Enter the value of 'p'
185
Now after introducing the Compressibility factor Z the equations rearranges like:
Z^3-Z^2+(A-B-B^2)Z-AB=0
Where A=ap/R^2*T^2.5
The value of A is =0.197925
The value of B is =0.0309303
The value of x2 is-1
The value of x3 is=0.166038
The value of x4 is=-0.00612188
Enter the value of the molecular weight of gas
44
Enter the value of the compressibility factor of gas
0.802637
Now calculating the density of gas
The value of the density of gas is = 1.68779
Enter the value of the molecular weight of liquid
44
Enter the value of the compressibility factor of liquid
0.052738
Now calculating the density of gas
The value of the density of liq is = 25.687
```

```
 a*x^3+b*x^2+c*x+d:
a=1

b=-1

c=0.166038

d=-0.00612188

A 3 Roots:
0.802637
0.052738
0.144625
```

5. Peng-Robinson equation of state

In 1976, Peng Robinson made improvements to the equation of state that made it simpler to predict liquid densities and other fluid characteristics close to the critical area. The equation that has been suggested is as follows:

$$p = \frac{RT}{V-b} - \frac{a\alpha}{V(V+b)+b(V-b)}$$

Peng and Robinson have also used the same approach for calculating α as in SRK EOS. i.e.:

$$\alpha = \left[1 + m\left(1 - \sqrt{T_r}\right)\right]^2$$

here,

m = 0.3796 + 1.54226ω – 0.2699ω^2

For heavier components, Peng and Robinson proposed a modified expression for calculating m with acentric values $\omega > 0.49$

m = 0.379642 + 1.48503ω – 0.1644ω^2+ 0.016667ω^3

Peng and Robinson EOS can be written in terms of compressibility factor through the following equation:

$$Z^3 + (B-1)Z^2 + (A - 3B^2 - 2B)Z - (AB - B^2B^3) = 0$$

Where A = $\frac{(a\alpha)p}{(RT)^2}$

B = $\frac{bp}{RT}$

and for hydrocarbon liquid and gaseous mixtures

$$(a\alpha)_m = \sum i \sum j\left[x_i x_j \sqrt{a_i a_j \alpha_i \alpha_j}\left(1 - k_{ij}\right)\right]$$

$$b_m = \sum i[x_i b_i]$$

With A = $\frac{(a\alpha)_m p}{(RT)^2}$

B = $\frac{b_m p}{RT}$

In case of gaseous mixture, replace x_i with y_i.

5.1 Following is the code to solve Peng-robinson equation of state:

```
// peng and robinson and its modifications EOS
#include<iostream>
#include<math.h>
using namespace std;
int main()
{

//finding out the pressure
// b is referred to as the co-volume
// first we have to calculate parameters a anb b
//
double Omega_a, Omega_b, Tc, Pc, R, a,b;

// a=omega_a(R2Tc2/Pc)
cout<<"Calculations for the parameter a"<<endl;
cout<<"Enter the value of R"<<endl;
```

```
cin>>R;

//double x=pow(R,2);
cout<<"Enter the value of Tc"<<endl;
cin>>Tc;
cout<<"Enter the value of Pc"<<endl;
cin>>Pc;
///double y=pow(Tc,2);

cout<<"Enter the value of Omega_a"<<endl;
cin>>Omega_a;
a=(Omega_a*R*R*Tc*Tc)/Pc;
cout<<"The value of parameter a is ="<<a<<endl;
cout<<"Calculations for the parameter b"<<endl;
cout<<"Enter the value of Omega_b"<<endl;

cin>>Omega_b;
b=Omega_b*(R*Tc/Pc);
cout<<"The value of parameter b is ="<<b<<endl;
// ||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||| \\
|||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||
//|||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||| \\


//now calculation for m begins
double w,m;
cout<<"Enter the value of w(acentric factor)"<<endl;
cin>>w;
double k=pow(w,2);

m=(0.3796+1.54226*w-0.2699*k);

cout<<"The value of m is ="<<m<<endl;
// ||||||||||||||||||||||||||||||||||||||||||||| \\
//Now calculations for the alpha begin

double alpha, Tr;
cout<<"Enter the value of m"<<endl;
cin>>m;

double v=sqrt(Tr);

double v1=(1+m)*(1-v);

alpha=pow(v1,2);
cout<<"The value of alpha is ="<<alpha<<endl;

//|||||||||||||||||||||||||||||||||||||||||||||||||||||||||||| \\
// ||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||| \\ //

double p,T;

// where small p is the pressure from the equation of state
```

```
//cout<<"Enter the volume"<<endl;
//cin>>V;
cout<<"Enter the Temperature"<<endl;
cin>>T;

//long j=(R*T/(V-b));
//
//long f=(a*alpha/(V*(V+b)+b*(V-b)));
//p=j-f;
cout<<"Enter the value of pressure  "<<endl;
cin>>p;

//Now calculation for A and B begin

double S=pow(R*T,2);
double A=a*alpha*p/S;
cout<<"Value of A is "<<A<<endl;
double B=b*p/(R*T);
cout<<"Value of B is "<<B<<endl;

//Now comes the equations into the compressibility factor

cout<<"New Equation becomes z^3+(B-1)Z^2+(A-3B^2-2B)Z-(AB-B^2-B^3)"<<endl;
double density_gas,density_liq;
double x1,x2,x3,x4;
x2=B-1;
cout<<"x2="<<x2<<endl;
x3=A-3*(B*B)-2*B;
cout<<"x3 ="<<x3<<endl;
x4=A*B-(B*B)-(B*B*B);
cout<<"x4= "<<x4<<endl;
double M_gas,M_liq,Z_gas,Z_liq;
cout<<"Enter the value of the molecular weight of gas"<<endl;
cin>>M_gas;
cout<<"Enter the value of the compressibility factor of gas"<<endl;
cin>>Z_gas;
cout<<"Now calculating the density of gas"<<endl;
density_gas= p*M_gas/(Z_gas*R*T);
cout<<"The value of the density of gas is = "<<density_gas<<endl;
/////////////
//////////////
cout<<"Enter the value of the molecular weight of liquid"<<endl;
cin>>M_liq;
cout<<"Enter the value of the compressibility factor of liquid"<<endl;
cin>>Z_liq;
cout<<"Now calculating the density of liquid"<<endl;
density_liq= p*M_liq/(Z_liq*R*T);
cout<<"The value of the density of liquid is = "<<density_liq<<endl;
return 0;
}
```

```
Calculations for the parameter a
Enter the value of R
10.73
Enter the value of Tc
666
Enter the value of Pc
616.3
Enter the value of Omega_a
0.42747
The value of parameter a is =35421
Calculations for the parameter b
Enter the value of Omega_b
0.08664
The value of parameter b is =1.00462
Enter the value of w(acentric factor)
0.1524
The value of m is =0.608372
Enter the value of m
0.608372
The value of alpha is =2.58686
Enter the Temperature
560
Enter the value of pressure
185
Value of A is 0.469495
Value of B is 0.0309303
New Equation becomes z^3+(B-1)Z^2+(A-3B^2-2B)Z-(AB-B^2-B^3)
x2=-0.96907
x3 =0.404764
x4= 0.0135353
Enter the value of the molecular weight of gas
44
Enter the value of the compressibility factor of gas
0.8625
Now calculating the density of gas
The value of the density of gas is = 1.57064
Enter the value of the molecular weight of liquid
44
```

6. Conclusion:

The code made it easy and error less to get the parameters and carry on comparing the values as to which equation is the better one to take forward.

7. References:

- Tarek Ahmed Book of Equation of States