2. Individual Equation

2.1 Peng-Robinson Equation

Thermodynamic properties are evaluated by Peng–Robinson equation[1]. No provision is made for transport properties at this moment.

2.1.1 The Names of Subroutine, Library File and Single Shot Program

Library File for UNIX:	`libjprmx.a`
Library File for DOS,Windows95/NT:	JPRMX.LIB
Single Shot Program for UNIX:	`prmx--ss`
Single Shot Program for DOS,Windows95/NT:	PRMX–SS.EXE

2.1.2 Reference State

By user's selecton of KSTAN, which is the first ARGUMENT of SUBROUTINE STNKAS, the reference state is determined as shown below. However for KOMBI≥4 or after SUBROUTINE START2(See 2.1.5) being CALLed, these imply KSTAN=0, irrespective of user's selection of KSTAN.

Table V-2.1-1 Reference State Specified by `KSTAN`

KSTAN	Reference State	value of enthalpy and entropy
0	298.15K, 1bar : ideal gas state of pure component	0.0kJ/kmol, 0.0kJ/(kmol·K)
1	273.15K : saturated liquid of pure component	200kJ/kg, 1.0kJ/(kg·K)
others	same with KSTAN= 0	

2.1.3 Missing SUBPROGRAM

Of the SUBPROGRAMs listed in 1.6, the next is missing in F–PROPATH by Peng–Robinson equation.

SUBTSP

2.1.4 Initialization by SUBROUTINE START1

When the mixture you are interested in is one of the mixtures for which table of constants are embedded in F–PROPATH, you can initialize F–PROPATH by writing three lines shown below. See 1.1 and Sample Program 1 of chapter 2.1.6.

```
CALL KPAMES(KPA, MESS)
CALL STNKAS(KSTAN, KAS)
CALL START1(J,KOMBI)
```

ARGUMENTs to the first two SUBROUTINEs are explained in 1.3. The last, START1, works as follows.

START1

SUBROUTINE START1(J,KOMBI)

input

INTEGER KOMBI : user selects one from the Table V–2.1–1.

output

INTEGER J : error detection code
−2 : invalid ARGUMENT(s)

The properties of the substances listed in Table V–2.1–1 are tabulated in Table V–2.1–2, which are used in Peng–Robinson PROPATH.

Table V-2.1-2 Combination of Substances Specified by `KOMBI`

KOMBI	component 1	component 2	interaction parameter	
1	R22	R123	0.0	[2]
2	R32	R125	0.013	[3]
3	R32	R134a	-0.01816	[4]
4	CH_4	C_2H_4	0.022	[5]
5	CH_4	C_2H_6	-0.003	[5]
6	CH_4	C_3H_6	0.033	[5]
7	CH_4	C_3H_8	0.016	[5]
8	CH_4	i–C_4H_{10}	0.026	[5]
9	CH_4	n–C_4H_{10}	0.019	[5]
10	CH_4	i–C_5H_{12}	-0.006	[5]
11	CH_4	n–C_5H_{12}	0.026	[5]
12	CH_4	n–C_6H_{14}	0.040	[5]
13	CH_4	C_6H_6	0.055	[5]
14	CH_4	C_6H_{12}	0.039	[5]
15	CH_4	n–C_7H_{16}	0.035	[5]
16	CH_4	n–C_8H_{18}	0.050	[5]
17	O_2	CO_2	0.09	[6]

Table V-2.1-3 Fundamental Constants of Pure Components tabulated in Table V-2.1-2

substance	M [kg/kmol]	T_c [K]	p_c [MPa]	v_c [m^3/kmol]	ω [-]	reference
R22	86.468	369.30	4.971	0.1660	0.2192	[7]
R123	152.931	456.86	3.6655	0.27500	0.2825	[7]
R32	52.024	351.26	5.778	0.12100	0.278	[3](T_c, p_c, ω), [7](M, v_c)
R125	120.022	339.19	3.631	0.20983	0.306	[3](T_c, p_c, ω), [7](M, v_c)
R134a	102.030	374.21	4.056	0.19812	0.326	[4](T_c, p_c, ω), [8](M, v_c)
CH_4	16.043	190.56	4.5990	0.09860	0.0115	[7]
CO_2	44.010	304.21	7.3830	0.09400	0.2276	[7]
C_2H_4	28.054	282.36	5.0318	0.12907	0.0852	[7]
C_2H_6	30.070	305.32	4.8720	0.14550	0.0995	[7]
C_3H_6	42.081	364.76	4.6126	0.18100	0.1424	[7]
C_3H_8	44.096	369.83	4.2480	0.20000	0.1523	[7]
n–C_4H_{10}	58.123	425.12	3.7960	0.25500	0.2002	[7]
i–C_4H_{10}	58.123	408.14	3.6480	0.26270	0.1770	[7]
i–C_5H_{12}	72.150	460.43	3.3812	0.30583	0.2275	[7]
n–C_5H_{12}	72.150	469.70	3.3700	0.31300	0.2515	[7]
C_6H_6	78.114	562.16	4.8980	0.25894	0.2108	[7]
C_6H_{12}	84.161	553.54	4.0748	0.30788	0.2118	[7]
n–C_6H_{14}	86.177	507.60	3.0250	0.37100	0.3013	[7]
n–C_7H_{16}	100.204	540.20	2.7400	0.42800	0.3495	[7]
n–C_8H_{18}	114.231	568.70	2.4900	0.48600	0.3996	[7]
O_2	31.999	154.58	5.0430	0.07340	0.0218	[7]

2.1.5 Initialization by SUBROUTINE START2

By the procedure described below, user can use F–PROPATH by Peng–Robinson equation for any mixture. However in that case a user has to transfer related constants of each component to F–PROPATH. They are molar mass, critical constants(temperature, pressure, volume), acentric factor, coefficients of isobaric specific heat equation at ideal gas state, and interaction parameter.

A user has to write the lines shown below before he or she makes reference to any F–PROPATH by Peng–Robinson equation SUBPROGRAM.

```
DIMENSION PR1(5),PR2(5),CP1(8),CP2(8)
  DATA STATEMENT for PR1,PR2,CP1,CP2
AKIJ=X
```

```
CALL KPAMES(KPA,MESS)
CALL STNKAS(KSTAN,KAS)
CALL START2(J,PR1,PR2,AKIJ,CP1,CP2)
```

PR1 and PR2 are arrays to which a user transfers constants for component 1 and 2, respectively. CP1 and CP2 are arrays to which a user trasfers coefficients of isobaric specific heat equation for component 1 and 2, respectively. AKIJ is the interaction parameter defined in reference [1].

Elements of PR1 and PR2 mean what are shown below.

PR1(1) : molar mass of component 1 [kg/kmol]
PR1(2) : critical temperature of component 1 [K]
PR1(3) : critical pressure of component 1 [Pa]
PR1(4) : critical volume of component 1 [m^3/kmol]
PR1(5) : acentric factor of component 1 [-]

PR2(1) : molar mass of component 2 [kg/kmol]
PR2(2) : critical temperature of component 2 [K]
PR2(3) : critical pressure of component 2 [Pa]
PR2(4) : critical volume of component 2 [m^3/kmol]
PR2(5) : acentric factor of component 2 [-]

A user is allowed to use one of the following two equation of isobaric specific heat at ideal gas state (T : temperature [K]).

(1) CP[J/(kmol·K)] $= A + B[(C/T)\sinh(C/T)]^2 + D[(E/T)\cosh(E/T)]$, CP*(1) = 1.0
(2) CP[J/(kmol·K)] $= A + BT + CT^2 + DT^3 + ET^4$, CP*(1) = 2.0

Elements of CP1 and CP2 mean what are shown below.

CP1(1) : number of equation 1.0 or 2.0 for component 1.
CP1(2) : value of A for component 1
CP1(3) : value of B for component 1
CP1(4) : value of C for component 1
CP1(5) : value of D for component 1
CP1(6) : value of E for component 1
CP1(7) : lower valid bound of the equation [K]
CP1(8) : upper valid bound of the equation [K]

CP2(1) : number of equation 1.0 or 2.0 for component 2.
CP2(2) : value of A for component 2
CP2(3) : value of B for component 2
CP2(4) : value of C for component 2
CP2(5) : value of D for component 2
CP2(6) : value of E for component 2
CP2(7) : lower valid bound of the equation [K]
CP2(8) : upper valid bound of the equation [K]

J is the error detection code. When PR1(2)>PR2(2), $T_{c1} > T_{c2}$, exchange between component 1 and 2 will occur and J= −1 will be returned. For other invalid ARGUMENT(s), J= −2 will occur.

2.1.6 Example of User's PROGRAM UNIT

Sample Program 1

```
      PROGRAM EX1
C-----------------------------------------------------------------
C    Peng-Robinson Equation
C    For R22-R123 mixture(KOMBI=1),this program calculates
C    temperature at buble point from Z=0.0 TO 1.0[kmol R22/kmol] at
C    every 0.1[kmol R22/kmol].
```

```
C-----------------------------------------------------------------
C
C-----------------------------------------------
C    T=[deg],P=[bar],amount of substance=[kmol]
C    standard state=(298.15[K],1[bar])
C-----------------------------------------------
      CALL KPAMES(1,1)
      CALL STNKAS(0,0)
      CALL START1(J,1)
C
C----------------------------------------
C   Calculation of pressure at buble point
C   using TBP and output results.
C----------------------------------------
      P=1.0
      DO 10 I=0,10
        Z=FLOAT(I)*0.1
        T=TBP(P,Z)
        WRITE(*,*) Z,T
   10 CONTINUE
      STOP
      END
C
C
C   result
C
C    0.000000E+00       27.395430
C    1.000000E-01        7.765078
C    2.000000E-01       -5.087575
C    3.000000E-01      -14.011260
C    4.000000E-01      -20.619320
C    5.000000E-01      -25.767130
C    6.000000E-01      -29.933280
C    7.000000E-01      -33.404360
C    8.000000E-01      -36.362870
C    9.000000E-01      -38.931340
C        1.000000      -41.196050
```

Sample Program 2

```
      PROGRAM EX2
C-----------------------------------------------------------------
C   Peng-Robinson Equation
C   For methane-ethylene mixture(KOMBI=4),this program calculates
C   VLE properties at P=1.0[bar] and T=150[K].
C-----------------------------------------------------------------
C
C----------------------------------------
C    T=[K],P=[Pa]
C    standard state=(298.15[K],1[bar])
C    amount of substance=[kmol]
C----------------------------------------
      CALL KPAMES(0,1)
      CALL STNKAS(0,0)
C
C-------------------------
C    Execution START1.
C-------------------------
      CALL START1(J,4)
C
C---------------------------------------------------------
C    Calculation of VLE properties on saturated state
C    and output results.
C---------------------------------------------------------
      P=1.0E5
      T=150.0
```

```
      CALL SUBXY(J,T,P,X,Y,VL,VV,HL,HV,SL,SV)
      HL=HL*1.0E-6
      HV=HV*1.0E-6
      SL=SL*1.0E-3
      SV=SV*1.0E-3
      WRITE(*,*) '  X[KMOL CH4/KMOL]=',X, '   Y[KMOL CH4/KMOL]=',Y
      WRITE(*,*) ' VL[M^3/KMOL]     =',VL,'  VV[M^3/KMOL]     =',VV
      WRITE(*,*) ' HL[MJ/KMOL]      =',HL,'  HV[MJ/KMOL]      =',HV
      WRITE(*,*) ' SL[KJ/KMOL]      =',SL,'  SV[KJ/KMOL]      =',SV
      STOP
      END
C
C
C....result
C
C   X[KMOL CH4/KMOL]=   5.313301E-02   Y[KMOL CH4/KMOL]=   7.212105E-01
C  VL[M^3/KMOL]     =   4.313929E-02  VV[M^3/KMOL]     =      12.211230
C  HL[MJ/KMOL]      =     -19.099360  HV[MJ/KMOL]      =      -5.234992
C  SL[KJ/KMOL]      =    -105.360700  SV[KJ/KMOL]      =     -19.152850
```

Sample Program 3

```
      PROGRAM EX3
C
C-----------------------------------------------------------------
C    Peng-Robinson Equation
C    For ethane-propane mixture,this program calculates property
C    at buble point at T=250[K] and Z=0.5[kmol C2H6/kmol].
C-----------------------------------------------------------------
C
C-------------------------------------------
C    Definition of array PR1,PR2,CP1 and CP2.
C-------------------------------------------
      DIMENSION PR1(5),PR2(5),CP1(8),CP2(8)
C
C---------------------------------------
C    T=[K],P=[Pa],quantity=[kmol]
C    standard state=(298.15[K],1[bar])
C---------------------------------------
      CALL KPAMES(0,1)
      CALL STNKAS(0,0)
C
C-------------------------------------------------------------------------
C    Putting fundamental constants into PR1 and PR2 using DATA STATEMENT.
C    DATA(PR1(I),I=1,5)/MW1[KG/KMOL],TC1[K],PC1[PA],VC1[M^3/KMOL],OMEGA1[-]/
C    DATA(PR2(I),I=1,5)/MW2[KG/KMOL],TC2[K],PC2[PA],VC2[M^3/KMOL],OMEGA2[-]/
C-------------------------------------------------------------------------
      DATA(PR1(I),I=1,5)/ 30.070, 305.42, 4.8801D6, 0.14792,  0.0990/
      DATA(PR2(I),I=1,5)/ 44.096, 369.82, 4.2492D6, 0.20288,  0.1518/
C
C-------------------------------------------------------------------------
C    Putting isobaric heat capacity at ideal gas state into CP1 and CP2
C    using DATA STATEMENT.
C    DATA(CP1(I),I=1,8)/EQUATION  NUMBER,A,B,C,D,E,TMIN[K],TMAX[K]/
C    DATA(CP2(I),I=1,8)/EQUATION  NUMBER,A,B,C,D,E,TMIN[K],TMAX[K]/
C-------------------------------------------------------------------------
      DATA(CP1(I),I=1,8)
     &  /1.0, 3.5650E4, 1.35200E5, 1.4300E3, 6.1800E4, 6.1200E2,
     &   100.0, 1500.0 /
      DATA(CP2(I),I=1,8)
     &  /1.0, 4.4000E4, 1.93800E5, 1.3690E3, 9.8000E4, 5.8300E2,
     &   100.0, 1500.0 /
C
C-----------------------------------------
C    Setting interaction parametar AKIJ.
C-----------------------------------------
```

```
      AKIJ=0.001
C
C-------------------------
C    Execution START2.
C-------------------------
      CALL START2(J,PR1,PR2,AKIJ,CP1,CP2)
C
C-----------------------------------------
C   Calculation of properties at buble point
C   using SUBPB and output results.
C-----------------------------------------
      T=250.0
      Z=0.5
      CALL SUBPB(J,T,P,Z,V,H,S)
      P=P*1.0E-6
      H=H*1.0E-6
      S=S*1.0E-3
      WRITE(*,*) ' P[MPA]      =',P
      WRITE(*,*) ' V[M^3/KMOL] =',V
      WRITE(*,*) ' H[MJ/KMOL]  =',H
      WRITE(*,*) ' S[KJ/KMOL]  =',S
      STOP
      END
C
C
C....result
C
C      P[MPA]      =   7.229552E-01
C      V[M^3/KMOL] =   6.797910E-02
C      H[MJ/KMOL]  =     -18.242270
C      S[KJ/KMOL]  =     -79.194690
```

Sample Program 4

```
      PROGRAM EX4
C---------------------------------------
C     Peng-Robinson Equation
C     For R32-R125 mixture (KOMBI=2),
C     this program execute only MKTABL.
C---------------------------------------
      CALL MKTABL(J,2)
      STOP
      END
C
C
C     You do not need to CALL SUBROUTINE
C     KPAMES, STNKAS and START1 before
C     CALLing MKTABL
C
C    result
C
C   FUNDAMENTAL CONSTANTS
C                                          R32              R125
C   MOLECULAR FORMULA                       CH2F2            CF3CHF2
C   RELATIVE MOLECULAR MASS [KG/KMOL]      52.024           120.020
C   GAS CONSTANT            [J/(KG*K)]    159.821            69.276
C   CRITICAL TEMPERATURE    [K]            351.60            339.40
C   CRITICAL PRESSURE       [MPA]          5.8302            3.6310
C   CRITICAL VOLUME         [M^3/KMOL]    .121000           .209830
C   ACENTRIC FACTOR         [-]             .2763             .3060
C   INTERACTION PATAMETER   [-]                      .0130

C   IDEAL GAS HEAT CAPACITY
C                                             R32              R125
C   EQUATION NUMBER                             1                2
C   A                                  .340600E+05      .236022E+05
```

```
C   B                                  .714400E+05        .283723E+03
C   C                                  .142200E+04       -.123028E+00
C   D                                  .394000E+05       -.567252E-04
C   E                                  .677000E+03        .000000E+00
C   LOW TEMPERATURE LIMIT  [K]               100.0              150.0
C   HIGH TEMPERATURE LIMIT [K]              1500.0              500.0
```

2.1.7 Sample Output of Single Shot Program

```
=========================================================================
|   Single Shot Program for Peng-Robinson Equation,                     |
|   an Application Program by F-PROPATH Ver.9.1                         |
|   Thermophysical Properties of Binary Mixtures                        |
|-----------------------------------------------------------------------|
|  ## First Menu ##                                                     |
| No.                      Current                                      |
| 1 --> Go to Second Menu                                               |
| 2 --> Select Mixture    (Component1 - Component2)                     |
|                         [ R32 - R125 ]                                |
| 3 --> Read Help                                                       |
| 4 --> Set Logfile       [OFF]                                         |
| 0 --> Quit                                                            |
=========================================================================
Input No.
3

 This is help for this program (PRMX-SS.EXE)
  Nomenclature
 ==== First Charactor ====
   H : Enthalpy
   P : Pressure
   S : Entropy
   T : Temperature
   V : Volume
   X : Component1 Composition of Liquid
   Y : Component1 Composition of Vapor
   Z : Total Composition of Component1
 ==== Second Charactor ====
   B : Bubble Point
   D : Dew Point
   L : Liquid
   V : Vapor

----- Hit RETURN Key -----

=========================================================================
|   Single Shot Program for Peng-Robinson Equation,                     |
|   an Application Program by F-PROPATH Ver.9.1                         |
|   Thermophysical Properties of Binary Mixtures                        |
|-----------------------------------------------------------------------|
|  ## First Menu ##                                                     |
| No.                      Current                                      |
| 1 --> Go to Second Menu                                               |
| 2 --> Select Mixture    (Component1 - Component2)                     |
|                         [ R32 - R125 ]                                |
| 3 --> Read Help                                                       |
| 4 --> Set Logfile       [OFF]                                         |
| 0 --> Quit                                                            |
=========================================================================
Input No.
4

 1: Logfile ON
 2: Logfile OFF
```

```
Input No.
1
Input Filename
PRMIX.LOG
=========================================================================
|   Single Shot Program for Peng-Robinson Equation,                     |
|   an Application Program by F-PROPATH Ver.9.1                         |
|   Thermophysical Properties of Binary Mixtures                        |
|-----------------------------------------------------------------------|
|  ## First Menu ##                                                     |
| No.                      Current                                      |
| 1 --> Go to Second Menu                                               |
| 2 --> Select Mixture    (Component1 - Component2)                     |
|                         [ R32 - R125 ]                                |
| 3 --> Read Help                                                       |
| 4 --> Set Logfile       [ON] PRMIX.LOG                                |
| 0 --> Quit                                                            |
=========================================================================
Input No.
2
====================================
| No.|  Component1 - Component2     |
|----|------------------------------|
|  1 | [ R22 - R123 ]               |
|  2 | [ R32 - R125 ]               |
|  3 | [ R32 - R134a ]              |
|  4 | [ CH4 - C2H4 ]               |
|  5 | [ CH4 - C2H6 ]               |
|  6 | [ CH4 - C3H6 ]               |
|  7 | [ CH4 - C3H8 ]               |
|  8 | [ CH4 - i-C4H10 ]            |
|  9 | [ CH4 - n-C4H10 ]            |
| 10 | [ CH4 - i-C5H12 ]            |
| 11 | [ CH4 - n-C5H12 ]            |
| 12 | [ CH4 - C6H14(n-Hexane) ]    |
| 13 | [ CH4 - C6H6(Benzene) ]      |
| 14 | [ CH4 - C6H12(Cyclohexane) ] |
| 15 | [ CH4 - C7H16(n-Heptan) ]    |
| 16 | [ CH4 - C8H18(n-Octane) ]    |
====================================
Input No.
1
=========================================================================
|   Single Shot Program for Peng-Robinson Equation,                     |
|   an Application Program by F-PROPATH Ver.9.1                         |
|   Thermophysical Properties of Binary Mixtures                        |
|-----------------------------------------------------------------------|
|  ## First Menu ##                                                     |
| No.                      Current                                      |
| 1 --> Go to Second Menu                                               |
| 2 --> Select Mixture    (Component1 - Component2)                     |
|                         [ R22 - R123 ]                                |
| 3 --> Read Help                                                       |
| 4 --> Set Logfile       [ON] PRMIX.LOG                                |
| 0 --> Quit                                                            |
=========================================================================
Input No.
1
============================================================
| ## Second Menu ##                                        |
|  <Single and Two Phase States>                           |
| No.  Input                   Output                      |
| 1 --(P,T,Z)-->    H  HL HV S  SL SV V  VL VV X  Y  QUALITY  |
| 2 --(P,Z,H)--> T     HL HV S  SL SV V  VL VV X  Y  QUALITY  |
| 3 --(P,Z,S)--> T  H  HL HV    SL SV V  VL VV X  Y  QUALITY  |
| 4 --(P,Z,V)--> T  H  HL HV S  SL SV    VL VV X  Y  QUALITY  |
|----------------------------------------------------------|
|  <Two Phase State>                                       |
| 5 --(P,Z)----> X=Z : TB HB SB VB    Y=Z : TD HD SD VD    |
| 6 --(T,Z)----> X=Z : PB HB SB VB    Y=Z : PD HD SD VD    |
| 7 --(P,T)----> Coexisting Phases: X  Y  HL HV SL SV VL VV |
```

```
|-------------------------------------------------------------|
| 8 -----------> Fundamental Constants                        |
| 9 -----------> Conversion of Composition and Relative       |
|                Molcular Mass of Mixture                     |
|10 -----------> Change System of Unit, and Standard Values of|
|                Enthalpy and Entropy                         |
|99 -----------> Return to First Menu                        |
| 0 -----------> Quit                                         |
===============================================================
Input No.
10

=====================================================
 No.                                 current
=====================================================
 1 --> Pressure and Temperature    [ Pa, K]
 2 --> Amount of Substance         [kmol]
 3 --> Standard Values of h and s  [1] Ideal Gas State
 0 --> Return to Second Menu
=====================================================
Input No.
1

===============================
 No.  <Pressure> <Temperature>
===============================
 1 -->   Pa            K
 2 -->   bar           C
 3 -->   bar           K
 4 -->   Pa            C
===============================
Input No.
1

=====================================================
 No.                                 current
=====================================================
 1 --> Pressure and Temperature    [ Pa, K]
 2 --> Amount of Substance         [kmol]
 3 --> Standard Values of h and s  [1] Ideal Gas State
 0 --> Return to Second Menu
=====================================================
Input No.
2

===========================
 No.   Amount of Substance
 1 -->   kmol
 2 -->   kg
===========================
Input No.
1

=====================================================
 No.                                 current
=====================================================
 1 --> Pressure and Temperature    [ Pa, K]
 2 --> Amount of Substance         [kmol]
 3 --> Standard Values of h and s  [2] IIR
 0 --> Return to Second Menu
=====================================================
Input No.
3

=============================================
 No.   Standard States and Values of h and s
 1 --> Ideal Gas State of Pure Components
       h=0.0[kJ/kg], s=0.0[kJ/(kg*K)]
       Pure Ideal Gases at 0[C], 1.0[bar]
 2 --> Convention of International Institute of
       Refrigeration(IIR):
```

```
       h=200[kJ/kg], s=1.0[kJ/(kg*K)]
       Saturated Pure Liquids at 0[C]
================================================
Input No.
1

=====================================================
 No.                                current
=====================================================
 1 --> Pressure and Temperature    [ Pa, K]
 2 --> Amount of Substance         [kmol]
 3 --> Standard Values of h and s  [1] Ideal Gas State
 0 --> Return to Second Menu
=====================================================
Input No.
0
============================================================
| ## Second Menu ##                                        |
 contents not shown
============================================================
Input No.
9

================================================================
 Conversion of Composition and Relative Molecular Mass of Mixture
================================================================

 1: [kmol/kmol] --> [kg/kg]     and Relative Molecular Mass of Mixture
 2: [kg/kg]     --> [kmol/kmol] and Relative Molecular Mass of Mixture
 0: Return to Second Menu
Input No.
1
Input Z[kmol/kmol]
0.5
 Z  =    .50000000[kmol/kmol]
 Z  =    .36118780[kg/kg]
 Relative Molecular Mass of Mixture =     119.69950000[kg/kmol]
 Relative Molecular Mass of [ R22 ]
    86.46800000[kg/kmol]
 Relative Molecular Mass of [ R123 ]
   152.93100000[kg/kmol]


 1: [kmol/kmol] --> [kg/kg]     and Relative Molecular Mass of Mixture
 2: [kg/kg]     --> [kmol/kmol] and Relative Molecular Mass of Mixture
 0: Return to Second Menu
Input No.
2
Input Z[kg/kg]
0.5
 Z  =    .50000000[kg/kg]
 Z  =    .63881220[kmol/kmol]
 Relative Molecular Mass of Mixture =     110.47360000[kg/kmol]
 Relative Molecular Mass of [ R22 ]
    86.46800000[kg/kmol]
 Relative Molecular Mass of [ R123 ]
   152.93100000[kg/kmol]


 1: [kmol/kmol] --> [kg/kg]     and Relative Molecular Mass of Mixture
 2: [kg/kg]     --> [kmol/kmol] and Relative Molecular Mass of Mixture
 0: Return to Second Menu
Input No.
0
============================================================
| ## Second Menu ##                                        |
 contents not shown
============================================================
Input No.
8
```

```
======================
 Fundamental Constants
======================
    <Constants>                [ R22 ]            [ R123 ]
Relative Molecular Mass       86.46800000         152.93100000  [kg/kmol]
Gas Constants                 96.15707000          54.36772000  [J/(kg*K)]
Critical Temperature         369.30000000         456.86000000  [K]
                              96.14999000         183.71000000  [C]
Critical Pressure             49.71000000          36.66000000  [bar]
Critical Volume             .16861500E+00        .27527600E+00  [m**3/kmol]
                            .19500280E-02        .18000010E-02  [m**3/kg]
Acentric Factor             .21920000E+00        .28160000E+00  [-]

----- Hit RETURN Key -----

============================================================
| ## Second Menu ##                                        |
 contents not shown
============================================================
Input No.
1

====================================
 (P,T,Z) --> H, S, V, QUALITY
             X, HL, SL, VL
             Y, HV, SV, VV
====================================
Input P[Pa]          (P=0 : Second Menu)
1000000.0
Input T[K]
300.0
Input Z[kmol/kmol]
0.5
T  =     300.00000000[K]          P  =    1000.00000000[kPa]
Z  =        .50000000[kmol/kmol]  H  =  -21618.98000000[kJ/kmol]
S  =     -65.95230000[kJ/(kmol*K)]V  =    .86610340E-01[m**3/kmol]
Liquid Region

Input P[Pa]          (P=0 : Second Menu)
100000.0
Input T[K]
250.0
Input Z[kmol/kmol]
0.7
T  =     250.00000000[K]          P  =     100.00000000[kPa]
Z  =        .70000000[kmol/kmol]  H  =  -15176.73000000[kJ/kmol]
S  =     -51.98681000[kJ/(kmol*K)]V  =    .10478000E+02[m**3/kmol]
X  =        .44631380[kmol/kmol]  Y  =        .93874230[kmol/kmol]
HL =  -28246.19000000[kJ/kmol]    HV =   -2877.16200000[kJ/kmol]
SL =     -98.26443000[kJ/(kmol*K)]SV =      -8.43526600[kJ/(kmol*K)]
VL =    .80284680E-01[m**3/kmol]  VV =    .20263210E+02[m**3/kmol]
QUALITY =       .51517370[kmol/kmol]

Input P[Pa]          (P=0 : Second Menu)
0
============================================================
| ## Second Menu ##                                        |
 contents not shown
============================================================
Input No.
2

====================================
 (P,Z,H) --> T, S, V, QUALITY
             X, HL, SL, VL
             Y, HV, SV, VV
====================================
Input P[Pa]          (P=0 : Second Menu)
1000000.0
Input Z[kmol/kmol]
0.5
```

```
Input H[J/kmol]
-21618000.0
T  =     300.00770000[K]          P  =    1000.00000000[kPa]
Z  =        .50000000[kmol/kmol]  H  =  -21618.00000000[kJ/kmol]
S  =     -65.94904000[kJ/(kmol*K)]V  =    .86611980E-01[m**3/kmol]
Liquid Region

Input P[Pa]          (P=0 : Second Menu)
0
============================================================
| ## Second Menu ##                                        |
 contents not shown
============================================================
Input No.
3

====================================
 (P,Z,S) --> T, H, V, QUALITY
             X, HL, SL, VL
             Y, HV, SV, VV
====================================
Input P[Pa]          (P=0 : Second Menu)
1000000.0
Input Z[kmol/kmol]
0.5
Input S[J/(kmol*K)]
-65952.0
T  =     300.00070000[K]          P  =    1000.00000000[kPa]
Z  =        .50000000[kmol/kmol]  H  =  -21618.89000000[kJ/kmol]
S  =     -65.95200000[kJ/(kmol*K)]V  =    .86610490E-01[m**3/kmol]
Liquid Region

Input P[Pa]          (P=0 : Second Menu)
0
============================================================
| ## Second Menu ##                                        |
 contents not shown
============================================================
Input No.
4

========================================
 (P,Z,V) --> T, H, S, QUALITY
             X, HL, SL, VL
             Y, HV, SV, VV
========================================
Input P[Pa]          (P=0 : Second Menu)
1000000.0
Input Z[kmol/kmol]
0.5
Input V[m**3/kmol]
0.08661034
T  =     300.00000000[K]          P  =    1000.00000000[kPa]
Z  =        .50000000[kmol/kmol]  H  =  -21618.97000000[kJ/kmol]
S  =     -65.95229000[kJ/(kmol*K)]V  =    .86610340E-01[m**3/kmol]
Liquid Region

Input P[Pa]          (P=0 : Second Menu)
0
============================================================
| ## Second Menu ##                                        |
 contents not shown
============================================================
Input No.
5

============================================
 (P,Z) --> X=Z : TB, HB, SB, VB
           Y=Z : TD, HD, SD, VD
============================================
Input P[Pa]          (P=0 : Second Menu)
```

```
100000.0
Input Z[kmol/kmol]
0.5
P  =     100.00000000[kPa]         Z  =         .50000000[kmol/kmol]
TB =     247.38290000[K]           TD =     284.15500000[K]
HB =  -27952.04000000[kJ/kmol]     HD =   -1276.68500000[kJ/kmol]
SB =     -98.41191000[kJ/(kmol*K)]SD =       1.58987600[kJ/(kmol*K)]
VB =    .78221300E-01[m**3/kmol]   VD =    .22974330E+02[m**3/kmol]

Input P[Pa]          (P=0 : Second Menu)
0
============================================================
| ## Second Menu ##                                        |
 contents not shown
============================================================
Input No.
6

=============================================
 (T,Z) --> X=Z : PB, HB, SB, VB
           Y=Z : PD, HD, SD, VD
=============================================
Input Z[kmol/kmol]   (Z < 0 : Second Menu)
0.5
Input T[K]
247.0
T  =     247.00000000[K]           Z  =         .50000000[kmol/kmol]
PB =      98.46436000[kPa]         PD =      17.06069000[kPa]
HB =  -27995.27000000[kJ/kmol]     HD =   -3909.78100000[kJ/kmol]
SB =     -98.65056000[kJ/(kmol*K)]SD =      -1.19786100[kJ/(kmol*K)]
VB =    .78173880E-01[m**3/kmol]   VD =    .11956650E+03[m**3/kmol]

Input Z[kmol/kmol]   (Z < 0 : Second Menu)
-1
============================================================
| ## Second Menu ##                                        |
 contents not shown
============================================================
Input No.
7

=============================================
 (P,T) --> Coexisting Phases
           X, HL, SL, VL
           Y, HV, SV, VV
=============================================
Input P[Pa]          (P=0 : Second Menu)
100000.0
Input T[K]
250.0
T  =     250.00000000[K]           P  =     100.00000000[kPa]
X  =        .44631380[kmol/kmol]   Y  =         .93874230[kmol/kmol]
HL =  -28246.19000000[kJ/kmol]     HV =   -2877.16200000[kJ/kmol]
SL =     -98.26443000[kJ/(kmol*K)]SV =      -8.43526600[kJ/(kmol*K)]
VL =    .80284680E-01[m**3/kmol]   VV =    .20263210E+02[m**3/kmol]

Input P[Pa]          (P=0 : Second Menu)
0
============================================================
| ## Second Menu ##                                        |
 contents not shown
============================================================
Input No.
99
=====================================================================
|   Single Shot Program for Peng-Robinson Equation,                  |
|   an Application Program by F-PROPATH Ver.9.1                      |
|   Thermophysical Properties of Binary Mixtures                     |
|--------------------------------------------------------------------|
|  ## First Menu ##                                                  |
| No.                      Current                                   |
```

```
| 1 --> Go to Second Menu                                              |
| 2 --> Select Mixture    (Component1 - Component2)                    |
|                         [ R22 - R123 ]                               |
| 3 --> Read Help                                                      |
| 4 --> Set Logfile       [ON] PRMIX.LOG                               |
| 0 --> Quit                                                           |
======================================================================
Input No.
0

***** See You Again ! *****
Stop - Program terminated.
```

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