PUBLICATIONS

1) Viscosities and partial molar volumes of tetramethyl ammonium chloride in ethyl alcohol-water mixtures,

2) Viscosities and partial molar volumes of [(CH₃)₄N]₂HgCl₄ in dioxane-water mixtures.

3) Viscosities and partial molar volumes of benzyl triethyl ammonium chloride in 1,4-Dioxane-water mixtures at 298K.
J. Ind. Chem. Soc. (In press)

PRESENTATIONS

1) Thirtieth Annual convention of chemists, 1993 at Calcutta.
   Paper No.34.

2) Thirtyfirst Annual convention of chemists, 1994 at Varanasi.
   Paper No. P-33.
Viscosities and Partial Molar Volumes of Tetramethyl Ammonium Chloride in Ethyl alcohol-Water Mixtures

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*Chemistry Department D. B. F. Datarnad College of Arts & Science, Solapur-413 002.

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In order to investigate the ion-ion and ion-solvent interactions1-4, viscosities and partial molar volumes from density measurements of tetramethylammonium chloride solution in various ethanol-water mixtures and at various temperatures have been measured.

Results and Discussion

An overall increase in viscosity was observed for compositions up to 60% ethanol (Fig. 1) and beyond which viscosity decreases. As the percentage of ethanol in the composition increases, viscosity increases due to intermolecular hydrogen bonding between alcohol and water molecules, as the molecular entities of type \((\text{EtOH})_m\text{(H}_2\text{O})_n\) \((m \geq n \ (m, n > 1))\) are formed. With the further addition of ethanol in the composition, the viscosity decreases due to dilution effect.

The impact of solute on viscosity may be understood in terms of Grunberg and Nissan5 equation,

\[
\ln \eta_{\text{mix}} = x_1 \ln \eta_1 + x_2 \ln \eta_2 + x_1 x_2 d' \quad (1)
\]

where \(\eta_{\text{mix}}, \eta_1\) and \(\eta_2\) are the viscosities of the mixture, ethanol and water respectively, \(x_1\) and \(x_2\) the mole fractions of the two components, \(d'\) is proportional to \(w/RT\) when \(w\) is the interchange energy6 or a measure of interactions. It is seen that the value of \(d'\) and excess viscosities are positive, suggesting complex formation involving solvent7. The interaction energy decreases with increasing percentage of ethanol as is evident from Fig. 1.

The relative viscosities have been analysed by Jones-Dole equation4,

\[
(\eta/\eta_0 - 1)/\sqrt{C} = A + B \sqrt{C} \quad (2)
\]

where the terms have their usual significance. The applicability of Jones-Dole equation was observed for the data. The positive values of \(A\), the Falken-Hagen8 coefficient indicate that strong ion-ion interaction may presumably be, due to...
unusual cation-cation and cation-anion interactions, while positive values of $B$ indicate that these interactions are strong enough and the extent of interaction is unaffected by the amount of ethanol. The values are given in Table 1.

The concentration dependence of apparent molar volumes has been explained in terms of Masson's equation:

$$\Phi_v = \Phi_v^0 + S_v^v \sqrt{C}$$

(3)

where $\Phi_v^0$ is the apparent molar volume at infinite dilution and $S_v^v$ is the experimental slope. The values of $\Phi_v^0$, $S_v^v$, along with standard errors, are listed in Table 2. The positive and large values of $S_v^v$ indicate the presence of strong ion-ion interactions. The decrease in $\Phi_v^0$ values for all the compositions indicate the presence of solvent-solvent interactions, and the increase in the $S_v^v$ values indicates formation of complex ions.

### Table 1: Least-squares Fit Parameters of Equation (3)

<table>
<thead>
<tr>
<th>Temp. °C</th>
<th>$\Phi_v^0$</th>
<th>S.D.</th>
<th>$S_v^v$</th>
<th>S.D.</th>
<th>$\Phi_v^0$</th>
<th>S.D.</th>
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<td>30% ethanol</td>
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<td>0.0462</td>
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### Table 2: Computed Parameters of Equation (3)

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<th>S.D.</th>
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<tr>
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<td>83.84</td>
<td>1.33</td>
<td>93.29</td>
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<table>
<thead>
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<th>$S_v^v$</th>
<th>S.D.</th>
<th>$\Phi_v^0$</th>
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<tr>
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<td>93.28</td>
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<td>68.36</td>
<td>1.16</td>
<td>78.32</td>
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<table>
<thead>
<tr>
<th>Temp. °C</th>
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<th>S.D.</th>
<th>$S_v^v$</th>
<th>S.D.</th>
<th>$\Phi_v^0$</th>
<th>S.D.</th>
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<td>90% ethanol</td>
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<tr>
<td>25</td>
<td>78.21</td>
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</tr>
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<td>1.78</td>
<td>39.05</td>
<td>46.85</td>
<td>1.78</td>
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</table>
\( \Delta \mu^* \), the contribution per mole of solute to the free energy of activation for viscous flow of the solution, has been determined using equation (4) as suggested by Feakings et al.\(^{10}\),

\[
B = \frac{\overline{v}_1 - \overline{v}_2}{1000} \, \frac{1000 + T \overline{v}_2}{RT} \left( \frac{\Delta \mu^* - \Delta \mu^*_s}{RT} \right)
\]  

(4)

where \( \overline{v}_1 \) and \( \overline{v}_2 \) are the partial molar volumes of the solvent and solute respectively. \( \Delta \mu^*_s \), the free energy of activation per mole of the pure solvent, is given by equation (5),

\[
\Delta \mu^*_s = RT \ln \left( \frac{\eta \overline{v}_2}{N_h} \right)
\]

(5)

for the mixed solvents. Each solvent mixture was treated as a pure solvent and the molar volume was taken as a mean value, which is defined as

\[
\overline{v}_i = (x_i M_1 + x_2 M_2) / \rho
\]

(6)

where \( x_1, M_1 \) and \( x_2, M_2 \) are mole fractions and molecular weights of water and ethanol respectively, and \( \rho \) is the density of the solvent mixtures. The activation parameters for viscous flow of the electrolyte are given in Table 3.

It is evident from Table 3 that \( \Delta \mu^*_s \) is practically constant in all solvent compositions. This implies that \( B \) coefficient is dependent mainly on \( \Delta \mu^*_s \) and (\( \overline{v}_1 - \overline{v}_2 \)) terms. \( \Delta F^\text{vis} \) and \( \Delta S^\text{vis} \) are highly positive, thus the formation of the transition state is less favourable. The results suggest that the activated state is reached by bond-breaking and distortion of intermolecular bonds.

**Experimental**

Tetramethylammonium chloride (A.R. grade; purified\(^1\)), ethanol and double-distilled water were used. Ethanol-water mixture of varying compositions as well as solutions of the electrolyte were made by weight within accuracy of 0.2 mg. Density and viscosity measurements were done using a pyknometer and a Cannon-Ubbelohde viscometer respectively. The details of the experimental procedure are similar to that reported earlier\(^2\).

The apparent molar volume (\( \phi_v \)) was calculated from the density data using equation (7),

\[
\phi_v = \frac{1000 (d_1 - d) + M_2}{Cd_1} \frac{d_2}{d_1}
\]

(7)

where \( C \) is molarity, \( d_1 \) and \( d \) are densities of the solvent and solution respectively, and \( M_2 \) is the molecular weight of the electrolyte.

**References**

Viscosities and partial molar volumes of [(CH₃)₄N]₂·HgCl₄ in dioxane-water mixtures

U R Kapadi* & S K Chavan
Department of Chemistry, Shivaji University, Centre for Post-Graduate Studies, Solapur 413 003, India

The viscosities and partial molar volumes of bis(tetra methyl ammonium) mercuric tetra chloride in dioxane-water mixtures of various composition in the temperature range 298-318 K have been measured. The experimental results of viscometry have been analysed using the Jones-Dole equation. Impact of solute on viscosity is studied in terms of Grunberg-Nissan parameter (d'). Mechanism of viscous flow has been studied in the light of activation parameters. Apparent molar volume ($\bar{v}$) of this electrolyte at different concentrations have been estimated using Masson’s equation.

Measurement of viscosities and partial molar volumes in solutions provide an excellent method for obtaining data on solute-solute and solute-solvent interaction. The majority of viscosity and density data so for reported arc for simple inorganic electrolytes. Viscosity of electrolytes with organic skeleton has been studied for quaternary ammonium salts. However, there has been no study on complexes of quaternary ammonium compounds with metal halides. The present paper deals with the study of these parameters on a complex of quaternary ammonium salt.

**Experimental procedure**

Bis(tetra methyl ammonium)mercuric tetra chloride [(CH₃)₄N]₂·HgCl₄ was prepared by dissolving tetra methyl ammonium chloride (10.96 g, 0.1 mol, BDH) and mercuric chloride (14.0 g, 0.05 mol, E Merck) separately in hot ethanol. The white precipitate obtained was dissolved on addition of excess of ethanol and was further crystallized by hot filtering. Needle like crystals formed, were recrystallized in ethanol and dried under vacuum. Dioxane-water mixtures of varying compositions as well as solutions of the electrolyte were made within an accuracy 0.1 mg, using a single pan balance. Density measurements were carried using pycnometer of about 7.4 mL volume with 10 cm long neck. Viscosities were measured using Cannon-Ubbelohde viscometer. A high precision thermostat with an accuracy of ±0.1°C was used throughout the work. The details of the experimental procedure is reported earlier.

**Results and discussion**

Grunberg and Nissan equation has been widely applied to the solutions of non-electrolytes and electrolytes as well.

$$\eta_{\text{mix}} = \eta_1 x_1 n_1 + \eta_2 x_2 n_2 + x_1 x_2 d' \quad \ldots (1)$$

where $\eta_{\text{mix}}$, $\eta_1$, and $\eta_2$ are the viscosities of the mixture dioxane and water, respectively; $x_1$, $x_2$ are the mol fractions of the two components; $d'$ is interaction parameter which is proportional to $w/RT$ where $w$ is the interchange energy. It is observed that the values of $d'$ and excess viscosities are positive, suggesting complex formation involving solvent. The values are given in Table 1.

The viscosity data are analysed in the light of Jones-Dole equation.

$$\eta/\eta_0 - 1)/\sqrt{C} = A + B/\sqrt{C} \quad \ldots (2)$$

where the terms have their usual significance. The constant $A$ (Falken-Hagen coefficient) and $B$ are measures of ion-ion interaction. The equation has been applied to the experimental data and it is found that the magnitudes of $A$ and $B$ are positive. This indicates the presence of strong ion-ion interaction which is independent of concentration of dioxane in the composition. The values are given in Table 2 along with standard deviation, ($\delta$) which is the square root of the arithmatic mean of the squares of the deviations from the mean.

**Table 1 — Values of $\Delta v_m$, $\Delta u_m$ and $d'$ in dioxane-water mixtures at 298 K**

<table>
<thead>
<tr>
<th>Dioxane wt %</th>
<th>$\Delta v_m$ kJ mol⁻¹</th>
<th>$\Delta u_m$ kJ mol⁻¹</th>
<th>$d'$</th>
</tr>
</thead>
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<td>5.62</td>
</tr>
<tr>
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<td>18.01</td>
<td>32.33</td>
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<td>18.08</td>
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</tr>
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<td>18.20</td>
<td>30.92</td>
<td>6.82</td>
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</tr>
<tr>
<td>90</td>
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*Author to whom correspondence should be addressed*
**Table 2—Least-squares fit parameter of Eq. (2) • %Dioxanc**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature, °C</th>
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<th>30</th>
<th>35</th>
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<td>0.019</td>
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<td>0.039</td>
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**Table 3—Computed parameters of Eq (6)**

<table>
<thead>
<tr>
<th>% Dioxane Parameters</th>
<th>Temperature, °C</th>
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<td>188.5</td>
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The viscosity data has also been analysed on the basis of a transition state treatment\textsuperscript{10} of relative viscosity of electrolytic solutions. The coefficient in terms of this theory is given by Eq. (3).

$$B = \frac{\nu^0_1 - \nu^0_2}{1000} + \frac{\nu^0_1}{1000} \left( \frac{\Delta \mu^0_2 - \Delta \mu^0_1}{RT} \right) \quad \ldots (3)$$

where $\nu^0_1$ and $\nu^0_2$ are the partial molar volumes of the solvent and the solute, respectively. $\Delta \mu^0_1$ and $\Delta \mu^0_2$ are the contributions per mole of solute to the free energy of activation for viscous flow of the solution and solvent, respectively. The later is given by

$$\Delta \mu^0_1 = RT \ln \left( \frac{\eta_1 \nu^0_1}{Nh} \right) \quad \ldots (4)$$

where $h$ is the Planck's constant and $N$ the Avogadro's number. The values of $\Delta \mu^0_1$ and $\Delta \mu^0_2$ are presented in Table 1. It is evident that $\Delta \mu^0_1$ is practically constant for all solvent compositions. This implies that $B$ coefficient is dependent mainly on $\Delta \mu^0_2$ and $(\nu^0_1 - \nu^0_2)$ term. $\Delta \mu^0_2$ values are positive and larger than $\Delta \mu^0_1$ suggesting that the formation of the transition state is less favourable.

The apparent molar volumes ($\phi_\text{s}$) was calculated from the density data using following equation

$$\phi_\text{s} = \frac{1000(d_1 - d)}{C \cdot d_1} + \frac{M_2}{d_1} \quad \ldots (5)$$

where $C$ is molarity, $d_1$ and $d$ are densities of solvent and solution, respectively, and $M_2$ is molecular weight of electrolyte. These values varied linearly with the square root of the concentration in conformity with the Masson's equation\textsuperscript{11}.

$$\phi_\text{s} = \phi_\text{s}^0 + S^* \sqrt{C} \quad \ldots (6)$$

where $\phi_\text{s}^0$ is the apparent molar volume at infinite dilution and $S^*$ is the experimental slope. The $\phi_\text{s}^0$ and $S^*$ values along with standard errors are listed in Table 3. The $\phi_\text{s}^0$ values are found to be large and positive indicating the presence of strong solute-solvent interactions while the large values of $S^*$ confirm the conclusion drawn on the basis of Jones-Dole equation.

References
TO WHOM IT MAY CONCERN

THIS IS TO CERTIFY THAT Mr. S. K. Chavan
ATTENDED
THE SESSIONS OF THE Physical CHEMISTRY
SECTION AND PRESENTED A PAPER ENTITLED "Viscosity
- Ethyl alcohol-water mixtures"
(ABSTRACT NO. 341) IN THE MORNING/AFTEERNON SESSION
ON 23-24/12/93

CHAIRMAN OF SESSION

SCIENTIST-IN-CHARGE

SECTION:

SECRETARY - CONVENTION COMMITTEE
Thirtyfirst Annual Convention of Chemists, 1994

Venue: Banaras Hindu University, Varanasi-221 005
December 21-24, 1994

Organised by Indian Chemical Society
92, Acharya Prafulla Chandra Road,
Calcutta-700 009 (Phone No. 350-3478)

From: Date: 23/12/94

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Prof. P. L. Majumdar
Dr. R. N. Mehta
Prof. A. Mishra
Prof. R. C. Srivastava

TO WHOM IT MAY CONCERN

This is to certify that Mr. Ms./Dr./Prof.
S. K. Chandra, Ph.D., Chemistry, Shivaji Univ.,
has attended the above Convention and presented a
paper No* P - 33.

No TA/DA was paid by the Society for the
purpose.

*Title of the paper
Conduction Melts at 398K.

Scientist-in-Charge

Section
* PROGRAMME CDVB

    SCAN ON RHG, TO FIND QZ, ALPHA

    INTEGER T
    COMMON C(20), Q(20), CK(20), TAU(20), F2(20), G2(20), RHO, 
        Q, TQ(20), RX(20), EL(20), QC(20), QCI(20), DQQ(20), RDI(20), 
        DQDF(20), RT2(20), DLQ(20), J, N, PVK, BETA, BR, QZ, SMSQ, SMDL, D, ETA, RB, BT 
    3, QK1(20), QK2(20)
    OPEN (7, FILE='UNB.DAT', STATUS='OLD')
    100 READ (7, 101, END=800) N, D, ETA, QZ, T
    101 FORMAT (I3, F10.2, F10.6, I3)
    * READ (7, 107) AST, RST, RIN, RND
    107 FORMAT (4F10.3)
    READ (7, 106) (C(J), J=1,N)
    106 FORMAT (8F10.3)
    READ (7, 126) (Q(J), J=1,N)
    CLOSE (UNIT=7)
    126 FORMAT (8F10.3)
    WRITE (*, 110) D, ETA
    110 FORMAT (' DIEL. CONST.=', F8.2, ' VISCOSITY=', F9.6)
    WRITE (*, 11)
    AL=AST
    IF (AL.LT.0.7) GO TO 500
    DLA=0.002
    GO TO 501
    500 DLA=0.01
    501 WRITE (*, 502) AST, DLA
    502 FORMAT (' AST=', F8.3, ' DLA=', F8.4)
    FPN=N
    DT=(273.16+T)*6
    BT=1.6708E5/DT

    BJQ=0.5*BT
    SQRDT=SQR(DT)
    BETA=92.501/(ETA*SQRDT)
    DTTH=DT*SQRDT
    DO 21 J=1,N
    CK(J)=C(J)*1.0E-4
    21 TAU(J)=(0.42016E7*SQR(C(J)))/DTTH
    RHO=RST
    51 RHO=RHO+RIN
    RB=RHO/BT
    PKR=0.002523*RHO*RHO*RHO*EXP(BR)
    WRITE (*, 114) RHQ, DJQ, RB
    114 FORMAT (' ***RHO=', F8.3, 'BJQ=', F8.3, ' RHO/BT=', F8.4)
    WRITE (*, 11)
PVK = PKR / (1. - AL)
CALL SUBGAM
M = 0
42 M = M + 1
IF (M .LT. 9) GO TO 38
WRITE(*,111) M, AL
111 FORMAT(* NO CONVERGENCE IN * CYCLES AT ALPHA = * F0.4 *)
WRITE(*,200)
WRITE(*,11)
M = 0
GO TO 45
38 CALL SUBOC
DO 32 J = 1, N
32 QC(J) = QC(J)
DO 33 J = 1, N
33 RT(J) = (Q(J) - QCI(J)) * DQQ(J)
AL = AL * (1. + DLA)
PVK = PKR / (1. - AL)
CALL SUBGAM
CALL SUBQC
DO 82 J = 1, N
82 QK1(J) = QC(J)
AL = ((1. - DLA) * AL) / (1. + DLA)
CALL SUBGAM
CALL SUBQC
AL = AL / (1. - AL)
PVK = PKR / (1. - AL)
DO 34 J = 1, N
34 RT2(J) = (Q(J) - QCI(J)) * DQQ(J)
SUM11 = 0.0
SUM13 = 0.0
SUM21 = 0.0
SUM22 = 0.0
SUM23 = 0.0
DO 35 J = 1, N
35 SUM11 = SUM11 + DQQ(J) * DQQ(J)
SUM13 = SUM13 + RT(J)
SUM21 = SUM21 + DQQ(J) * DQQ(J)
SUM22 = SUM22 + DQQ(J) * DQQ(J)
SUM23 = SUM23 + RT2(J)
DET = SUM11 * SUM22 - SUM21 * SUM23
DETO = SUM13 * SUM22 - SUM21 * SUM23
DETK = SUM11 * SUM23 - SUM21 * SUM13
DQZ = DETQ / DET
QZ = QZ + DQZ
AL = AL + DPK
PKV = PKR / (1. - AL)
WRITE(*, 90) QZ, DQZ, AL, DPK, M
1.', F9.5, ' AT M =', F13.)
   IF (AL.GT.0.0 .AND. AL.LT.1.0) GO TO 37
WRITE(*, 130) AL, M
130 FORMAT (* IMPOSSIBLE ALPHA =', F8.3, ' AT M =', F13.)
   AL = ABS
   IF (RHO.LT. (RND - 0.01)) GO TO 51
GO TO 100
37 CALL SUBBAM
50 TSQ = ABS(DIQ/DQZ)
   IF (TSQ.GT.0.0001) GO TO 42
   TSA = ABS(DPK/AL)
   IF (TSA.GT.0.001) GO TO 42
45 CALL SUBFIN
   SIGMA = SQRT(SMGR/(FPN-2.0))
   RAT = (SIGMA/QZ)*100.0
   A11 = ABS(SUM11/DET)
   A22 = ABS(SUM22/DET)
   SEQ = SIGMA*SQRT(A22)
   SGK = SIGMA*SQRT(A11)
   FE = AL*(AL/(1.-AL))
   PK5 = AL/ (1.-AL)
   WRITE(*, 611) PKK, PKS, FE, AL, PKV
   IAL =', F8.4, ' PKV =', F10.3)
   WRITE(*, 14) QZ, GG, AL, SGK, RHO
14 FORMAT (* NNZG VALUES QZ =', F8.3, ' PM =', F5.3, ' AND AL =
   1.', F9.5, ' PM =', F9.5, ' FOR RH =', F7.3)
   WRITE(*, 123) SIGMA, SMDL, RAT
123 FORMAT (* STD. DEVN. =', F6.3, ' WITH SUM-DELTA =', F6.4)
   WRITE(*, 11)
   WRITE(*, 200)
   IF (RHO.LT. (RND - 0.01)) GO TO 51
GO TO 100
800 STOP
END

SUBROUTINE SUBBAM
COMMON Q(20), G(20), CK(20), TAU(20), F2(20), G2(20), CB(20), RHO,
IAL, TT(20), RX(20), EL(20), OC(20), OCI(20), DQ(20), RT(20),
ZDQ(20), RZ(20), DLQ(20), J, N, PVK, BETA, BR, QZ, SMB, SMDL, D, ETA, RB, BT
3, QK1(20), QK2(20)
Bi = 1.0
DO 207 J = 1, N
SUBROUTINE SUBUC

COMMON C(20), Q(20), CK(20), TAU(20), F2(20), G2(20), CB(20), RHO, AL, TT(20), RX(20), EL(20), QC(20), QC1(20), DQO(20), RTI(20), DQ(20), RT2(20), DLO(20), J, N, PKV, BETA, BR, OZ, BMSG, SMDL, ETA, RB, BT, 3, QK1(20), QK2(20)

DO 300 J=1,N

BC=BETA*SQRT(CG(J))

T=2.0*SQRT(G2(J))

TT(J)=T

BRT=T/TB

TB=T*T

TC=T/TT

DXZ=BRT/(6.0*1.70711*(1.+T)*(1.+0.70711*T))

ALG=ALOG(T)

IF(T.GT.0.6)GO TO 330

IF(T.GT.0.3)GO TO 331

H2=-2.6951+18.438*T-15.335*T^2+20.476*T*C^1.4

GO TO 332

331 H2=-2.0722+12.452*T-15.304*T^2+6.0045*T*C

GO TO 332

330 H2=-1.0425+6.9012*T-5.8121*T^2

332 DXV=(BC/QZ)*BRT*(H2/16.-ALG/B.)

IF(T.GT.0.4)GO TO 351

FH2=0.13842-0.25289*T+0.16281*T^2-0.44868*T*C

FH3=0.0084869-0.029776*T+0.045001*T^2-0.26344*T*C

H1=0.19295-0.18508*T-0.32106*T^2+0.40243*T*C

GO TO 352

351 FH2=0.13858-0.23739*T+0.14034*T^2-0.04150*T*C

FH3=0.20742-0.31145*T+0.06461*T^2

352 RX(J)=DXZ+DXV*BRT*BRT*(ALG/12.+FH2+BRT*FH3)

EL(J)=BC*(1./((1.+T)+BRT*(ALG/8.+H1/2.)))

QC(J)=(OZ*(1.+RX(J)))+EL(J))*(1.-(1.-G2(J)))*AL)

300 CONTINUE
SUBROUTINE SUBFIN

COMMON C(20), Q(20), CK(20), TAU(20), F2(20), G2(20), CB(20), RHO,
   1AL, TL(20), RX(20), EL(20), QC(20), DCI(20), DQQ(20), RTI(20),
2DQ(20), RT2(20), DLQ(20), J, N, PKV, ETA, BR, QZ, SMSQ, SMDL, D, ETA, RB, BT

CALL SUBQC

SMSQ=0.0
SMDL=0.0

DO 184 J=1, N
DLQ(J)=QC(J)-Q(J)
SMDL=SMDL+DLQ(J)

184 SMSQ=SMSQ+DLQ(J)*DLQ(J)
RD=1.0/D

TLK=ALOG(PKV)*0.4343
WP=QZ*ETA

WRITE(*,147)
147 FORMAT(' 10000C  Q  QC-Q  GAMMA  ACT. SQ  T' )
WRITE(*,148)(C(J),Q(J),DLQ(J),G2(J),F2(J),TT(J),J=1,N)

WRITE(*,124)

WRITE(*,105)RD, TLK, WP
105 FORMAT('RCIP= ',F7.5, '  10-LGG-K = ',F7.3, '  WP = ',F7.4)
 FP=N
SIGMA=SQRT(SMSQ/(FP-2.0))
RT=100.0*SIGMA/QZ
WRITE(*,124)
124 FORMAT(' ***SMDL=',F6.3, '  100*SIG/QZ=',F6.4, '  ' )