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        NASA-GLENN CHEMICAL EQUILIBRIUM PROGRAM CEA2, MAY 21, 2004
                    BY  BONNIE MCBRIDE AND SANFORD GORDON
     REFS: NASA RP-1311, PART I, 1994 AND NASA RP-1311, PART II, 1996

 ******************************************************************************



 problem   case=Ethanol o/f=1.2,1.4,1.6,1.8,2.0,2.2,
       rocket  equilibrium  tcest,k=3800
   p,bar=10,
   pi/p=10,
 react
   fuel=C2H5OH(L) moles=1.0  t,k=298.15
   oxid=O2 moles=1.0  t,k=298.15
 output  transport
     plot t p gam m son cp h
 end

 OPTIONS: TP=F  HP=F  SP=F  TV=F  UV=F  SV=F  DETN=F  SHOCK=F  REFL=F  INCD=F
 RKT=T  FROZ=F  EQL=T  IONS=F  SIUNIT=T  DEBUGF=F  SHKDBG=F  DETDBG=F  TRNSPT=T

 TRACE= 0.00E+00  S/R= 0.000000E+00  H/R= 0.000000E+00  U/R= 0.000000E+00

 Pc,BAR =    10.000000

 Pc/P =    10.0000

 SUBSONIC AREA RATIOS =

 SUPERSONIC AREA RATIOS =

 NFZ=  1  Mdot/Ac= 0.000000E+00  Ac/At= 0.000000E+00

    REACTANT           MOLES    (ENERGY/R),K   TEMP,K  DENSITY
        EXPLODED FORMULA
 F: C2H5OH(L)        1.000000  -0.333766E+05   298.15  0.0000
          C  2.00000  H  6.00000  O  1.00000
 O: O2               1.000000  -0.154035E-05   298.15  0.0000
          O  2.00000

  SPECIES BEING CONSIDERED IN THIS SYSTEM
 (CONDENSED PHASE MAY HAVE NAME LISTED SEVERAL TIMES)
  LAST thermo.inp UPDATE:    9/09/04

  g 7/97  *C               tpis79  *CH              g 4/02  CH2
  g 4/02  CH3              g11/00  CH2OH            g 7/00  CH3O
  g 8/99  CH4              g 7/00  CH3OH           srd 01  CH3OOH
  tpis79  *CO              g 9/99  *CO2             tpis91  COOH
  tpis91  *C2              g 6/01  C2H              g 1/91  C2H2,acetylene
  g 5/01  C2H2,vinylidene  g 4/02  CH2CO,ketene     g 3/02  O(CH)2O
  srd 01  HO(CO)2OH        g 7/01  C2H3,vinyl       g 6/96  CH3CO,acetyl
  g 1/00  C2H4             g 8/88  C2H4O,ethylen-o  g 8/88  CH3CHO,ethanal
  g 6/00  CH3COOH          srd 01  OHCH2COOH        g 7/00  C2H5
```

g 7/00	C2H6	g 8/88	C2H5OH	g 7/00	CH3OCH3
srd 01	CH3O2CH3	g 8/00	C2O	tpis79	*C3
n 4/98	C3H3,1-propynl	n 4/98	C3H3,2-propynl	g 2/00	C3H4,allene
g 1/00	C3H4,propyne	g 5/90	C3H4,cyclo-	g 3/01	C3H5,allyl
g 2/00	C3H6,propylene	g 1/00	C3H6,cyclo-	g 6/01	C3H6O,propylox
g 6/97	C3H6O,acetone	g 1/02	C3H6O,propanal	g 7/01	C3H7,n-propyl
g 9/85	C3H7,i-propyl	g 2/00	C3H8	g 2/00	C3H8O,1propanol
g 2/00	C3H8O,2propanol	g 7/88	C3O2	g tpis	*C4
g 7/01	C4H2,butadiyne	g 8/00	C4H4,1,3-cyclo-	n10/92	C4H6,butadiene
n10/93	C4H6,1butyne	n10/93	C4H6,2butyne	g 8/00	C4H6,cyclo-
n 4/88	C4H8,1-butene	n 4/88	C4H8,cis2-buten	n 4/88	C4H8,tr2-butene
n 4/88	C4H8,isobutene	g 8/00	C4H8,cyclo-	g10/00	(CH3COOH)2
n10/84	C4H9,n-butyl	n10/84	C4H9,i-butyl	g 1/93	C4H9,s-butyl
g 1/93	C4H9,t-butyl	g12/00	C4H10,n-butane	g 8/00	C4H10,isobutane
g 8/00	*C5	g 5/90	C5H6,1,3cyclo-	g 1/93	C5H8,cyclo-
n 4/87	C5H10,1-pentene	g 2/01	C5H10,cyclo-	n10/84	C5H11,pentyl
g 1/93	C5H11,t-pentyl	n10/85	C5H12,n-pentane	n10/85	C5H12,i-pentane
n10/85	CH3C(CH3)2CH3	g 2/93	C6H2	g11/00	C6H5,phenyl
g 8/00	C6H5O,phenoxy	g 8/00	C6H6	g 8/00	C6H5OH,phenol
g 1/93	C6H10,cyclo-	n 4/87	C6H12,1-hexene	g 6/90	C6H12,cyclo-
n10/83	C6H13,n-hexyl	g 6/01	C6H14,n-hexane	g 7/01	C7H7,benzyl
g 1/93	C7H8	g12/00	C7H8O,cresol-mx	n 4/87	C7H14,1-heptene
n10/83	C7H15,n-heptyl	n10/85	C7H16,n-heptane	n10/85	C7H16,2-methylh
n 4/89	C8H8,styrene	n10/86	C8H10,ethylbenz	n 4/87	C8H16,1-octene
n10/83	C8H17,n-octyl	n 4/85	C8H18,n-octane	n 4/85	C8H18,isooctane
n10/83	C9H19,n-nonyl	g 3/01	C10H8,naphthale	n10/83	C10H21,n-decyl
g 8/00	C12H9,o-bipheny	g 8/00	C12H10,biphenyl	g 6/97	*H
g 1/01	HCO	g 6/01	HCCO	g 4/02	HO2
tpis78	*H2	g 5/01	HCHO,formaldehy	g 6/01	HCOOH
g 8/89	H2O	g 6/99	H2O2	g 6/01	(HCOOH)2
g 5/97	*O	g 4/02	*OH	tpis89	*O2
g 8/01	O3	n 4/83	C(gr)	n 4/83	C(gr)
n 4/83	C(gr)	g11/99	H2O(cr)	g 8/01	H2O(L)
g 8/01	H2O(L)				

SPECIES WITH TRANSPORT PROPERTIES

PURE SPECIES

C	CH4	CH3OH	CO
CO2	C2H2,acetylene		
C2H4	C2H6	C2H5OH	H
H2	H2O		
O	OH	O2	

BINARY INTERACTIONS

C	O
CH4	O2
CO	CO2
CO	O2
CO2	H2
CO2	H2O
CO2	O2
H	H2
H	O
H2	H2O

H2 O2
H2O O2
O O2

O/F = 1.200000

ENTHALPY (KG-MOL)(K)/KG	EFFECTIVE FUEL h(2)/R	EFFECTIVE OXIDANT h(1)/R	MIXTURE h0/R
	-0.72450014E+03	-0.48137850E-07	-0.32931825E+03

KG-FORM.WT./KG	bi(2)	bi(1)	b0i
*C	0.43413669E-01	0.00000000E+00	0.19733486E-01
*H	0.13024101E+00	0.00000000E+00	0.59200458E-01
*O	0.21706834E-01	0.62502344E-01	0.43958930E-01

POINT	ITN	T	C	H	O
1	22	2858.658	-14.547	-10.007	-17.958
Pinf/Pt = 1.752674					
2	4	2643.861	-14.479	-10.140	-18.685
Pinf/Pt = 1.761153					
2	2	2642.002	-14.477	-10.141	-18.692
Pinf/Pt = 1.761231					
2	1	2641.985	-14.477	-10.141	-18.692
3	4	1985.833	-13.535	-10.486	-22.080

THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

Pin = 145.0 PSIA
CASE = Ethanol

	REACTANT	MOLES	ENERGY KJ/KG-MOL	TEMP K
FUEL	C2H5OH(L)	1.0000000	-277510.001	298.150
OXIDANT	O2	1.0000000	0.000	298.150

O/F= 1.20000 %FUEL= 45.454545 R,EQ.RATIO= 1.571176 PHI,EQ.RATIO= 1.736482

	CHAMBER	THROAT	EXIT
Pinf/P	1.0000	1.7612	10.000
P, BAR	10.000	5.6778	1.0000
T, K	2858.66	2641.98	1985.83
RHO, KG/CU M	8.4246-1	5.2044-1	1.2272-1
H, KJ/KG	-2738.12	-3382.70	-5032.21
U, KJ/KG	-3925.12	-4473.68	-5847.11
G, KJ/KG	-39667.2	-37512.8	-30685.9
S, KJ/(KG)(K)	12.9183	12.9183	12.9183
M, (1/n)	20.024	20.135	20.262
(dLV/dLP)t	-1.00638	-1.00343	-1.00021
(dLV/dLT)p	1.1355	1.0778	1.0059

Cp, KJ/(KG)(K)	3.5454	3.0523	2.3100
GAMMAs	1.1691	1.1816	1.2188
SON VEL,M/SEC	1178.0	1135.4	996.6
MACH NUMBER	0.000	1.000	2.149

TRANSPORT PROPERTIES (GASES ONLY)
  CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

VISC,MILLIPOISE	0.91842	0.86830	0.70891

WITH EQUILIBRIUM REACTIONS

Cp, KJ/(KG)(K)	3.5454	3.0523	2.3100
CONDUCTIVITY	7.2003	5.5601	2.7339
PRANDTL NUMBER	0.4522	0.4767	0.5990

WITH FROZEN REACTIONS

Cp, KJ/(KG)(K)	2.3185	2.2928	2.1864
CONDUCTIVITY	3.3994	3.1602	2.4450
PRANDTL NUMBER	0.6264	0.6300	0.6339

PERFORMANCE PARAMETERS

Ae/At	1.0000	2.2480
CSTAR, M/SEC	1692.3	1692.3
CF	0.6709	1.2657
Ivac, M/SEC	2096.3	2522.4
Isp, M/SEC	1135.4	2142.0

MOLE FRACTIONS

*CO	0.30801	0.30559	0.28917
*CO2	0.08713	0.09174	0.11066
*H	0.01395	0.00850	0.00069
*H2	0.19325	0.19822	0.21929
H2O	0.38798	0.39130	0.38005
*O	0.00037	0.00011	0.00000
*OH	0.00901	0.00444	0.00013
*O2	0.00030	0.00009	0.00000

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

*C	*CH	CH2	CH3	CH2OH
CH3O	CH4	CH3OH	CH3OOH	COOH
*C2	C2H	C2H2,acetylene	C2H2,vinylidene	CH2CO,ketene
O(CH)2O	HO(CO)2OH	C2H3,vinyl	CH3CO,acetyl	C2H4
C2H4O,ethylen-o	CH3CHO,ethanal	CH3COOH	OHCH2COOH	C2H5
C2H6	C2H5OH	CH3OCH3	CH3O2CH3	C2O
*C3	C3H3,1-propynl	C3H3,2-propynl	C3H4,allene	C3H4,propyne
C3H4,cyclo-	C3H5,allyl	C3H6,propylene	C3H6,cyclo-	C3H6O,propylox
C3H6O,acetone	C3H6O,propanal	C3H7,n-propyl	C3H7,i-propyl	C3H8
C3H8O,1propanol	C3H8O,2propanol	C3O2	*C4	C4H2,butadiyne

C4H4,1,3-cyclo-	C4H6,butadiene	C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-
C4H8,1-butene	C4H8,cis2-buten	C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-
(CH3COOH)2	C4H9,n-butyl	C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl
C4H10,n-butane	C4H10,isobutane	*C5	C5H6,1,3cyclo-	C5H8,cyclo-
C5H10,1-pentene	C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane
C5H12,i-pentane	CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy
C6H6	C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-
C6H13,n-hexyl	C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx
C7H14,1-heptene	C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene
C8H10,ethylbenz	C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane
C9H19,n-nonyl	C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl
HCO	HCCO	HO2	HCHO,formaldehy	HCOOH
H2O2	(HCOOH)2	O3	C(gr)	H2O(cr)
H2O(L)				

O/F = 1.400000

	EFFECTIVE FUEL	EFFECTIVE OXIDANT	MIXTURE
ENTHALPY	h(2)/R	h(1)/R	h0/R
(KG-MOL)(K)/KG	-0.72450014E+03	-0.48137850E-07	-0.30187506E+03

KG-FORM.WT./KG	bi(2)	bi(1)	b0i
*C	0.43413669E-01	0.00000000E+00	0.18089029E-01
*H	0.13024101E+00	0.00000000E+00	0.54267086E-01
*O	0.21706834E-01	0.62502344E-01	0.45504215E-01

POINT	ITN	T	C	H	O
1	4	3098.072	-15.798	-10.360	-16.787
Pinf/Pt = 1.732738					
2	4	2928.566	-15.967	-10.533	-17.217
Pinf/Pt = 1.735314					
2	2	2928.107	-15.967	-10.533	-17.218
3	5	2360.749	-15.956	-11.000	-19.330

THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

Pin = 145.0 PSIA
CASE = Ethanol

	REACTANT	MOLES	ENERGY KJ/KG-MOL	TEMP K
FUEL	C2H5OH(L)	1.0000000	-277510.001	298.150
OXIDANT	O2	1.0000000	0.000	298.150

O/F= 1.40000 %FUEL= 41.666667 R,EQ.RATIO= 1.391335 PHI,EQ.RATIO= 1.488413

FileEditor:KAL-Eta-p.out

	CHAMBER	THROAT	EXIT
Pinf/P	1.0000	1.7353	10.000
P, BAR	10.000	5.7626	1.0000
T, K	3098.07	2928.11	2360.75
RHO, KG/CU M	8.2858-1	5.1051-1	1.1219-1
H, KJ/KG	-2509.94	-3153.49	-4921.69
U, KJ/KG	-3716.83	-4282.29	-5813.05
G, KJ/KG	-41519.4	-40022.9	-34647.1
S, KJ/(KG)(K)	12.5915	12.5915	12.5915
M, (1/n)	21.343	21.568	22.021
(dLV/dLP)t	-1.01993	-1.01403	-1.00216
(dLV/dLT)p	1.4028	1.2996	1.0554
Cp, KJ/(KG)(K)	5.4738	4.7520	2.7490
GAMMAs	1.1365	1.1402	1.1776
SON VEL,M/SEC	1171.2	1134.5	1024.6
MACH NUMBER	0.000	1.000	2.144

TRANSPORT PROPERTIES (GASES ONLY)
CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

VISC,MILLIPOISE	0.99827	0.96036	0.82556

WITH EQUILIBRIUM REACTIONS

Cp, KJ/(KG)(K)	5.4738	4.7520	2.7490
CONDUCTIVITY	11.4468	9.5376	4.2881
PRANDTL NUMBER	0.4774	0.4785	0.5293

WITH FROZEN REACTIONS

Cp, KJ/(KG)(K)	2.2595	2.2442	2.1748
CONDUCTIVITY	3.4677	3.2882	2.6883
PRANDTL NUMBER	0.6504	0.6555	0.6679

PERFORMANCE PARAMETERS

Ae/At	1.0000	2.3506
CSTAR, M/SEC	1726.6	1726.6
CF	0.6571	1.2720
Ivac, M/SEC	2129.5	2602.1
Isp, M/SEC	1134.5	2196.2

MOLE FRACTIONS

*CO	0.26814	0.26488	0.25359
*CO2	0.11793	0.12525	0.14474
*H	0.02387	0.01877	0.00489
HO2	0.00001	0.00000	0.00000
*H2	0.12710	0.12756	0.13791
H2O	0.42468	0.43731	0.45558
*O	0.00323	0.00183	0.00007
*OH	0.03079	0.02191	0.00313
*O2	0.00424	0.00249	0.00009

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

*C	*CH	CH2	CH3	CH2OH
CH3O	CH4	CH3OH	CH3OOH	COOH
*C2	C2H	C2H2,acetylene	C2H2,vinylidene	CH2CO,ketene
O(CH)2O	HO(CO)2OH	C2H3,vinyl	CH3CO,acetyl	C2H4
C2H4O,ethylen-o	CH3CHO,ethanal	CH3COOH	OHCH2COOH	C2H5
C2H6	C2H5OH	CH3OCH3	CH3O2CH3	C2O
*C3	C3H3,1-propynl	C3H3,2-propynl	C3H4,allene	C3H4,propyne
C3H4,cyclo-	C3H5,allyl	C3H6,propylene	C3H6,cyclo-	C3H6O,propylox
C3H6O,acetone	C3H6O,propanal	C3H7,n-propyl	C3H7,i-propyl	C3H8
C3H8O,1propanol	C3H8O,2propanol	C3O2	*C4	C4H2,butadiyne
C4H4,1,3-cyclo-	C4H6,butadiene	C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-
C4H8,1-butene	C4H8,cis2-buten	C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-
(CH3COOH)2	C4H9,n-butyl	C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl
C4H10,n-butane	C4H10,isobutane	*C5	C5H6,1,3cyclo-	C5H8,cyclo-
C5H10,1-pentene	C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane
C5H12,i-pentane	CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy
C6H6	C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-
C6H13,n-hexyl	C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx
C7H14,1-heptene	C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene
C8H10,ethylbenz	C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane
C9H19,n-nonyl	C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl
HCO	HCCO	HCHO,formaldehy	HCOOH	H2O2
(HCOOH)2	O3	C(gr)	H2O(cr)	H2O(L)

O/F = 1.600000

ENTHALPY (KG-MOL)(K)/KG	EFFECTIVE FUEL h(2)/R	EFFECTIVE OXIDANT h(1)/R	MIXTURE h0/R
	-0.72450014E+03	-0.48137850E-07	-0.27865390E+03

KG-FORM.WT./KG	bi(2)	bi(1)	b0i
*C	0.43413669E-01	0.00000000E+00	0.16697565E-01
*H	0.13024101E+00	0.00000000E+00	0.50092695E-01
*O	0.21706834E-01	0.62502344E-01	0.46811763E-01

POINT	ITN	T	C	H	O
1	5	3200.978	-16.575	-10.602	-16.153
Pinf/Pt = 1.724780					
2	4	3055.626	-16.876	-10.805	-16.446
Pinf/Pt = 1.723561					
2	2	3055.810	-16.876	-10.805	-16.446
3	5	2611.869	-17.644	-11.433	-17.686

THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

Pin = 145.0 PSIA
CASE = Ethanol

	REACTANT	MOLES	ENERGY KJ/KG-MOL	TEMP K
FUEL	C2H5OH(L)	1.0000000	-277510.001	298.150
OXIDANT	O2	1.0000000	0.000	298.150

O/F= 1.60000 %FUEL= 38.461538 R,EQ.RATIO= 1.248436 PHI,EQ.RATIO= 1.302361

	CHAMBER	THROAT	EXIT
Pinf/P	1.0000	1.7236	10.000
P, BAR	10.000	5.8019	1.0000
T, K	3200.98	3055.81	2611.87
RHO, KG/CU M	8.4047-1	5.1749-1	1.0813-1
H, KJ/KG	-2316.87	-2945.68	-4740.10
U, KJ/KG	-3506.68	-4066.85	-5664.92
G, KJ/KG	-41625.3	-40471.4	-36814.2
S, KJ/(KG)(K)	12.2801	12.2801	12.2801
M, (1/n)	22.369	22.662	23.482
(dLV/dLP)t	-1.03591	-1.03033	-1.01182
(dLV/dLT)p	1.7078	1.6278	1.2872
Cp, KJ/(KG)(K)	7.4329	7.0026	4.6570
GAMMAs	1.1235	1.1217	1.1289
SON VEL,M/SEC	1156.2	1121.4	1021.8
MACH NUMBER	0.000	1.000	2.155

TRANSPORT PROPERTIES (GASES ONLY)
CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

VISC,MILLIPOISE	1.0404	1.0096	0.91070

WITH EQUILIBRIUM REACTIONS

Cp, KJ/(KG)(K)	7.4329	7.0026	4.6570
CONDUCTIVITY	15.2180	13.7457	8.0212
PRANDTL NUMBER	0.5082	0.5143	0.5287

WITH FROZEN REACTIONS

Cp, KJ/(KG)(K)	2.1964	2.1859	2.1442
CONDUCTIVITY	3.4350	3.2913	2.8453
PRANDTL NUMBER	0.6653	0.6705	0.6863

PERFORMANCE PARAMETERS

Ae/At	1.0000	2.4379
CSTAR, M/SEC	1723.1	1723.1
CF	0.6508	1.2776
Ivac, M/SEC	2121.2	2621.6
Isp, M/SEC	1121.4	2201.5

MOLE FRACTIONS

*CO	0.22909	0.22296	0.20338
*CO2	0.14440	0.15543	0.18871
*H	0.02647	0.02273	0.01152
HO2	0.00003	0.00002	0.00000
*H2	0.08801	0.08559	0.08158
H2O	0.43210	0.44832	0.49186
*O	0.00895	0.00663	0.00148
*OH	0.05376	0.04462	0.01785
*O2	0.01716	0.01370	0.00362

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

*C	*CH	CH2	CH3	CH2OH
CH3O	CH4	CH3OH	CH3OOH	COOH
*C2	C2H	C2H2,acetylene	C2H2,vinylidene	CH2CO,ketene
O(CH)2O	HO(CO)2OH	C2H3,vinyl	CH3CO,acetyl	C2H4
C2H4O,ethylen-o	CH3CHO,ethanal	CH3COOH	OHCH2COOH	C2H5
C2H6	C2H5OH	CH3OCH3	CH3O2CH3	C2O
*C3	C3H3,1-propynl	C3H3,2-propynl	C3H4,allene	C3H4,propyne
C3H4,cyclo-	C3H5,allyl	C3H6,propylene	C3H6,cyclo-	C3H6O,propylox
C3H6O,acetone	C3H6O,propanal	C3H7,n-propyl	C3H7,i-propyl	C3H8
C3H8O,1propanol	C3H8O,2propanol	C3O2	*C4	C4H2,butadiyne
C4H4,1,3-cyclo-	C4H6,butadiene	C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-
C4H8,1-butene	C4H8,cis2-buten	C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-
(CH3COOH)2	C4H9,n-butyl	C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl
C4H10,n-butane	C4H10,isobutane	*C5	C5H6,1,3cyclo-	C5H8,cyclo-
C5H10,1-pentene	C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane
C5H12,i-pentane	CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy
C6H6	C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-
C6H13,n-hexyl	C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx
C7H14,1-heptene	C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene
C8H10,ethylbenz	C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane
C9H19,n-nonyl	C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl
HCO	HCCO	HCHO,formaldehy	HCOOH	H2O2
(HCOOH)2	O3	C(gr)	H2O(cr)	H2O(L)

O/F = 1.800000

	EFFECTIVE FUEL	EFFECTIVE OXIDANT	MIXTURE
ENTHALPY	h(2)/R	h(1)/R	h0/R
(KG-MOL)(K)/KG	-0.72450014E+03	-0.48137850E-07	-0.25875005E+03

KG-FORM.WT./KG	bi(2)	bi(1)	b0i
*C	0.43413669E-01	0.00000000E+00	0.15504882E-01
*H	0.13024101E+00	0.00000000E+00	0.46514645E-01
*O	0.21706834E-01	0.62502344E-01	0.47932519E-01

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```
 POINT ITN      T            C           H           O
   1    4    3238.147     -17.105     -10.775     -15.776
 Pinf/Pt = 1.722113
   2    3    3101.069     -17.470     -10.994     -16.015
 Pinf/Pt = 1.719897
   2    2    3101.383     -17.469     -10.993     -16.015
   3    4    2707.165     -18.626     -11.715     -16.903
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THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

Pin = 145.0 PSIA
CASE = Ethanol

	REACTANT	MOLES	ENERGY KJ/KG-MOL	TEMP K
FUEL	C2H5OH(L)	1.0000000	-277510.001	298.150
OXIDANT	O2	1.0000000	0.000	298.150

O/F= 1.80000 %FUEL= 35.714286 R,EQ.RATIO= 1.132156 PHI,EQ.RATIO= 1.157654

	CHAMBER	THROAT	EXIT
Pinf/P	1.0000	1.7199	10.000
P, BAR	10.000	5.8143	1.0000
T, K	3238.15	3101.38	2707.17
RHO, KG/CU M	8.6172-1	5.3043-1	1.0894-1
H, KJ/KG	-2151.38	-2762.98	-4529.73
U, KJ/KG	-3311.85	-3859.14	-5447.70
G, KJ/KG	-40993.1	-39964.2	-37002.3
S, KJ/(KG)(K)	11.9950	11.9950	11.9950
M, (1/n)	23.201	23.525	24.520
(dLV/dLP)t	-1.04534	-1.04111	-1.02659
(dLV/dLT)p	1.8862	1.8413	1.6287
Cp, KJ/(KG)(K)	8.3979	8.2653	7.1823
GAMMAs	1.1192	1.1159	1.1094
SON VEL,M/SEC	1139.6	1106.0	1009.2
MACH NUMBER	0.000	1.000	2.161

TRANSPORT PROPERTIES (GASES ONLY)
  CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

VISC,MILLIPOISE	1.0610	1.0325	0.94881

 WITH EQUILIBRIUM REACTIONS

Cp, KJ/(KG)(K)	8.3979	8.2653	7.1823
CONDUCTIVITY	17.3104	16.3380	12.3292
PRANDTL NUMBER	0.5147	0.5223	0.5527

 WITH FROZEN REACTIONS

Cp, KJ/(KG)(K)	2.1367	2.1278	2.0968
CONDUCTIVITY	3.3609	3.2337	2.8636
PRANDTL NUMBER	0.6745	0.6794	0.6947

PERFORMANCE PARAMETERS

Ae/At	1.0000	2.4692
CSTAR, M/SEC	1704.6	1704.6
CF	0.6488	1.2795
Ivac, M/SEC	2097.1	2601.9
Isp, M/SEC	1106.0	2181.0

MOLE FRACTIONS

*CO	0.19585	0.18765	0.15883
*CO2	0.16386	0.17709	0.22135
*H	0.02512	0.02204	0.01340
HO2	0.00007	0.00004	0.00001
*H2	0.06498	0.06183	0.05252
H2O	0.42704	0.44364	0.49331
H2O2	0.00001	0.00000	0.00000
*O	0.01492	0.01217	0.00524
*OH	0.06994	0.06121	0.03547
*O2	0.03822	0.03432	0.01987

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

*C	*CH	CH2	CH3	CH2OH
CH3O	CH4	CH3OH	CH3OOH	COOH
*C2	C2H	C2H2,acetylene	C2H2,vinylidene	CH2CO,ketene
O(CH)2O	HO(CO)2OH	C2H3,vinyl	CH3CO,acetyl	C2H4
C2H4O,ethylen-o	CH3CHO,ethanal	CH3COOH	OHCH2COOH	C2H5
C2H6	C2H5OH	CH3OCH3	CH3O2CH3	C2O
*C3	C3H3,1-propynl	C3H3,2-propynl	C3H4,allene	C3H4,propyne
C3H4,cyclo-	C3H5,allyl	C3H6,propylene	C3H6,cyclo-	C3H6O,propylox
C3H6O,acetone	C3H6O,propanal	C3H7,n-propyl	C3H7,i-propyl	C3H8
C3H8O,1propanol	C3H8O,2propanol	C3O2	*C4	C4H2,butadiyne
C4H4,1,3-cyclo-	C4H6,butadiene	C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-
C4H8,1-butene	C4H8,cis2-buten	C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-
(CH3COOH)2	C4H9,n-butyl	C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl
C4H10,n-butane	C4H10,isobutane	*C5	C5H6,1,3cyclo-	C5H8,cyclo-
C5H10,1-pentene	C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane
C5H12,i-pentane	CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy
C6H6	C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-
C6H13,n-hexyl	C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx
C7H14,1-heptene	C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene
C8H10,ethylbenz	C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane
C9H19,n-nonyl	C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl
HCO	HCCO	HCHO,formaldehy	HCOOH	(HCOOH)2
O3	C(gr)	H2O(cr)	H2O(L)	

O/F = 2.000000

ENTHALPY	EFFECTIVE FUEL h(2)/R	EFFECTIVE OXIDANT h(1)/R	MIXTURE h0/R
(KG-MOL)(K)/KG	-0.72450014E+03	-0.48137850E-07	-0.24150005E+03

KG-FORM.WT./KG	bi(2)	bi(1)	b0i
*C	0.43413669E-01	0.00000000E+00	0.14471223E-01
*H	0.13024101E+00	0.00000000E+00	0.43413669E-01
*O	0.21706834E-01	0.62502344E-01	0.48903841E-01

POINT	ITN	T	C	H	O
1	4	3246.029	-17.510	-10.908	-15.522
Pinf/Pt = 1.721171					
2	3	3111.708	-17.911	-11.136	-15.738
Pinf/Pt = 1.718759					
2	2	3112.043	-17.910	-11.135	-15.737
3	4	2730.708	-19.257	-11.904	-16.496

THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

Pin = 145.0 PSIA
CASE = Ethanol

	REACTANT	MOLES	ENERGY KJ/KG-MOL	TEMP K
FUEL	C2H5OH(L)	1.0000000	-277510.001	298.150
OXIDANT	O2	1.0000000	0.000	298.150

O/F= 2.00000 %FUEL= 33.333333 R,EQ.RATIO= 1.035691 PHI,EQ.RATIO= 1.041889

	CHAMBER	THROAT	EXIT
Pinf/P	1.0000	1.7188	10.000
P, BAR	10.000	5.8182	1.0000
T, K	3246.03	3112.04	2730.71
RHO, KG/CU M	8.8584-1	5.4521-1	1.1147-1
H, KJ/KG	-2007.95	-2602.40	-4325.78
U, KJ/KG	-3136.82	-3669.55	-5222.91
G, KJ/KG	-40107.5	-39129.3	-36376.8
S, KJ/(KG)(K)	11.7373	11.7373	11.7373
M, (1/n)	23.908	24.247	25.308
(dLV/dLP)t	-1.04855	-1.04487	-1.03290
(dLV/dLT)p	1.9492	1.9177	1.7732
Cp, KJ/(KG)(K)	8.5905	8.5618	8.0617
GAMMAs	1.1176	1.1141	1.1053
SON VEL,M/SEC	1123.2	1090.4	995.8
MACH NUMBER	0.000	1.000	2.162

TRANSPORT PROPERTIES (GASES ONLY)
CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

VISC,MILLIPOISE	1.0703	1.0424	0.96193

WITH EQUILIBRIUM REACTIONS

Cp, KJ/(KG)(K)	8.5905	8.5618	8.0617
CONDUCTIVITY	17.9139	17.1856	14.2745
PRANDTL NUMBER	0.5133	0.5193	0.5433

WITH FROZEN REACTIONS

Cp, KJ/(KG)(K)	2.0823	2.0742	2.0464
CONDUCTIVITY	3.2742	3.1555	2.8151
PRANDTL NUMBER	0.6807	0.6852	0.6993

PERFORMANCE PARAMETERS

Ae/At	1.0000	2.4770
CSTAR, M/SEC	1682.2	1682.2
CF	0.6482	1.2799
Ivac, M/SEC	2069.1	2569.7
Isp, M/SEC	1090.4	2153.1

MOLE FRACTIONS

*CO	0.16820	0.15883	0.12558
*CO2	0.17778	0.19205	0.24066
*H	0.02254	0.01982	0.01229
HO2	0.00010	0.00007	0.00002
*H2	0.05020	0.04705	0.03708
H2O	0.41753	0.43371	0.48306
H2O2	0.00001	0.00001	0.00000
*O	0.01976	0.01672	0.00884
*OH	0.07982	0.07122	0.04611
*O2	0.06406	0.06052	0.04636

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

*C	*CH	CH2	CH3	CH2OH
CH3O	CH4	CH3OH	CH3OOH	COOH
*C2	C2H	C2H2,acetylene	C2H2,vinylidene	CH2CO,ketene
O(CH)2O	HO(CO)2OH	C2H3,vinyl	CH3CO,acetyl	C2H4
C2H4O,ethylen-o	CH3CHO,ethanal	CH3COOH	OHCH2COOH	C2H5
C2H6	C2H5OH	CH3OCH3	CH3O2CH3	C2O
*C3	C3H3,1-propynl	C3H3,2-propynl	C3H4,allene	C3H4,propyne
C3H4,cyclo-	C3H5,allyl	C3H6,propylene	C3H6,cyclo-	C3H6O,propylox
C3H6O,acetone	C3H6O,propanal	C3H7,n-propyl	C3H7,i-propyl	C3H8
C3H8O,1propanol	C3H8O,2propanol	C3O2	*C4	C4H2,butadiyne
C4H4,1,3-cyclo-	C4H6,butadiene	C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-
C4H8,1-butene	C4H8,cis2-buten	C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-

(CH3COOH)2	C4H9,n-butyl	C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl
C4H10,n-butane	C4H10,isobutane	*C5	C5H6,1,3cyclo-	C5H8,cyclo-
C5H10,1-pentene	C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane
C5H12,i-pentane	CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy
C6H6	C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-
C6H13,n-hexyl	C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx
C7H14,1-heptene	C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene
C8H10,ethylbenz	C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane
C9H19,n-nonyl	C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl
HCO	HCCO	HCHO,formaldehy	HCOOH	(HCOOH)2
O3	C(gr)	H2O(cr)	H2O(L)	

O/F = 2.200000

ENTHALPY (KG-MOL)(K)/KG	EFFECTIVE FUEL h(2)/R	EFFECTIVE OXIDANT h(1)/R	MIXTURE h0/R
	-0.72450014E+03	-0.48137850E-07	-0.22640629E+03

KG-FORM.WT./KG	bi(2)	bi(1)	b0i
*C	0.43413669E-01	0.00000000E+00	0.13566772E-01
*H	0.13024101E+00	0.00000000E+00	0.40700315E-01
*O	0.21706834E-01	0.62502344E-01	0.49753747E-01

POINT	ITN	T	C	H	O
1	4	3239.589	-17.845	-11.019	-15.336
Pinf/Pt = 1.720877					
2	3	3106.076	-18.273	-11.253	-15.539
Pinf/Pt = 1.718483					
2	2	3106.407	-18.272	-11.252	-15.539
3	4	2727.057	-19.744	-12.051	-16.237

THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

Pin = 145.0 PSIA
CASE = Ethanol

	REACTANT	MOLES	ENERGY KJ/KG-MOL	TEMP K
FUEL	C2H5OH(L)	1.0000000	-277510.001	298.150
OXIDANT	O2	1.0000000	0.000	298.150

O/F= 2.20000 %FUEL= 31.250000 R,EQ.RATIO= 0.954374 PHI,EQ.RATIO= 0.947172

	CHAMBER	THROAT	EXIT
Pinf/P	1.0000	1.7185	10.000
P, BAR	10.000	5.8191	1.0000

T, K	3239.59	3106.41	2727.06
RHO, KG/CU M	9.1059-1	5.6040-1	1.1449-1
H, KJ/KG	-1882.46	-2460.65	-4138.19
U, KJ/KG	-2980.65	-3499.02	-5011.64
G, KJ/KG	-39152.9	-38198.9	-35512.1
S, KJ/(KG)(K)	11.5047	11.5047	11.5047
M, (1/n)	24.527	24.874	25.959
(dLV/dLP)t	-1.04828	-1.04465	-1.03279
(dLV/dLT)p	1.9484	1.9173	1.7738
Cp, KJ/(KG)(K)	8.4026	8.3762	7.8909
GAMMAs	1.1172	1.1136	1.1049
SON VEL,M/SEC	1107.6	1075.4	982.4
MACH NUMBER	0.000	1.000	2.162

TRANSPORT PROPERTIES (GASES ONLY)
CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

VISC,MILLIPOISE	1.0735	1.0454	0.96451

WITH EQUILIBRIUM REACTIONS

Cp, KJ/(KG)(K)	8.4026	8.3762	7.8909
CONDUCTIVITY	17.6337	16.9681	14.2821
PRANDTL NUMBER	0.5115	0.5161	0.5329

WITH FROZEN REACTIONS

Cp, KJ/(KG)(K)	2.0334	2.0255	1.9988
CONDUCTIVITY	3.1856	3.0720	2.7451
PRANDTL NUMBER	0.6852	0.6893	0.7023

PERFORMANCE PARAMETERS

Ae/At	1.0000	2.4781
CSTAR, M/SEC	1659.4	1659.4
CF	0.6480	1.2800
Ivac, M/SEC	2041.0	2535.2
Isp, M/SEC	1075.3	2124.0

MOLE FRACTIONS

*CO	0.14505	0.13509	0.10013
*CO2	0.18770	0.20237	0.25206
*H	0.01978	0.01730	0.01044
HO2	0.00013	0.00009	0.00003
*H2	0.03998	0.03702	0.02750
H2O	0.40655	0.42217	0.46993
H2O2	0.00001	0.00001	0.00000
*O	0.02327	0.01996	0.01125
*OH	0.08528	0.07660	0.05122
*O2	0.09225	0.08941	0.07744

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS

WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

*C	*CH	CH2	CH3	CH2OH
CH3O	CH4	CH3OH	CH3OOH	COOH
*C2	C2H	C2H2,acetylene	C2H2,vinylidene	CH2CO,ketene
O(CH)2O	HO(CO)2OH	C2H3,vinyl	CH3CO,acetyl	C2H4
C2H4O,ethylen-o	CH3CHO,ethanal	CH3COOH	OHCH2COOH	C2H5
C2H6	C2H5OH	CH3OCH3	CH3O2CH3	C2O
*C3	C3H3,1-propynl	C3H3,2-propynl	C3H4,allene	C3H4,propyne
C3H4,cyclo-	C3H5,allyl	C3H6,propylene	C3H6,cyclo-	C3H6O,propylox
C3H6O,acetone	C3H6O,propanal	C3H7,n-propyl	C3H7,i-propyl	C3H8
C3H8O,1propanol	C3H8O,2propanol	C3O2	*C4	C4H2,butadiyne
C4H4,1,3-cyclo-	C4H6,butadiene	C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-
C4H8,1-butene	C4H8,cis2-buten	C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-
(CH3COOH)2	C4H9,n-butyl	C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl
C4H10,n-butane	C4H10,isobutane	*C5	C5H6,1,3cyclo-	C5H8,cyclo-
C5H10,1-pentene	C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane
C5H12,i-pentane	CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy
C6H6	C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-
C6H13,n-hexyl	C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx
C7H14,1-heptene	C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene
C8H10,ethylbenz	C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane
C9H19,n-nonyl	C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl
HCO	HCCO	HCHO,formaldehy	HCOOH	(HCOOH)2
O3	C(gr)	H2O(cr)	H2O(L)	