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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

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 problem    o/f=5.0,
     rocket  equilibrium  frozen  nfz=1
   p,bar=20,
   sub,ae/at=16,15.239,10.677,
   sup,ae/at=9.332,17.559,
 react
   fuel=H2 t,k=300
   oxid=O2
 output  transport
 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=T  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 =    20.000000

 Pc/P =

 SUBSONIC AREA RATIOS =    16.0000    15.2390    10.6770

 SUPERSONIC AREA RATIOS =     9.3320    17.5590

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

 WARNING!!  AMOUNT MISSING FOR REACTANT  1.
 PROGRAM SETS WEIGHT PERCENT = 100. (REACT)

 WARNING!!  AMOUNT MISSING FOR REACTANT  2.
 PROGRAM SETS WEIGHT PERCENT = 100. (REACT)

    REACTANT          WT.FRAC   (ENERGY/R),K   TEMP,K  DENSITY
        EXPLODED FORMULA
 F: H2               1.000000   0.641759E+01   300.00  0.0000
          H  2.00000
 O: O2               1.000000   0.000000E+00     0.00  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 6/97  *H               g 4/02  HO2              tpis78  *H2
  g 8/89  H2O              g 6/99  H2O2             g 5/97  *O
  g 4/02  *OH              tpis89  *O2              g 8/01  O3
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 g11/99  H2O(cr)          g 8/01  H2O(L)           g 8/01  H2O(L)

SPECIES WITH TRANSPORT PROPERTIES

       PURE SPECIES

 H                 H2                H2O               O
 OH                O2

    BINARY INTERACTIONS

    H                H2
    H                O
    H2               H2O
    H2               O2
    H2O              O2
    O                O2


O/F =   5.000000

                       EFFECTIVE FUEL     EFFECTIVE OXIDANT        MIXTURE
ENTHALPY                   h(2)/R             h(1)/R               h0/R
(KG-MOL)(K)/KG        0.31835169E+01     0.00000000E+00      0.53058615E+00

KG-FORM.WT./KG             bi(2)              bi(1)               b0i
 *H                   0.99212255E+00     0.00000000E+00      0.16535376E+00
 *O                   0.00000000E+00     0.62502344E-01      0.52085287E-01

POINT ITN      T            H           O
  1    9    3300.330      -9.618     -17.053
Pinf/Pt = 1.736008
  2    4    3116.198      -9.788     -17.454
Pinf/Pt = 1.737194
  2    2    3115.972      -9.788     -17.455
  3    1    3300.286      -9.619     -17.053
  3    2    3300.207      -9.619     -17.053
  3    2    3300.111      -9.619     -17.053
  3    1    3300.066      -9.619     -17.053
  3    1    3300.061      -9.619     -17.053
  4    2    3300.282      -9.619     -17.053
  4    2    3300.194      -9.619     -17.053
  4    2    3300.088      -9.619     -17.053
  4    1    3300.039      -9.619     -17.053
  4    1    3300.034      -9.619     -17.053
  5    2    3300.229      -9.619     -17.053
  5    2    3300.049      -9.619     -17.053
  5    2    3299.834      -9.619     -17.054
  5    2    3299.736      -9.619     -17.054
  5    1    3299.726      -9.619     -17.054
  6    5    1849.767     -10.751     -23.092
  6    2    1861.521     -10.743     -23.000
  7    3    1592.555     -10.919     -25.471
  7    2    1583.370     -10.925     -25.571
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THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

Pin = 290.1 PSIA
CASE =

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
FUEL	H2	1.0000000	53.359	300.000
OXIDANT	O2	1.0000000	0.000	0.000

O/F= 5.00000 %FUEL= 16.666667 R,EQ.RATIO= 1.587337 PHI,EQ.RATIO= 1.587337

	CHAMBER	THROAT	EXIT	EXIT	EXIT	EXIT	EXIT
Pinf/P	1.0000	1.7372	1.0008	1.0009	1.0018	69.109	162.71
P, BAR	20.000	11.513	19.984	19.983	19.964	0.28940	0.12292
T, K	3300.33	3115.97	3300.06	3300.03	3299.73	1861.52	1583.37
RHO, KG/CU M	8.4142-1	5.1890-1	8.4084-1	8.4078-1	8.4011-1	2.2607-2	1.1293-2
H, KJ/KG	4.4116	-1264.18	2.5246	2.3312	0.16677	-7670.09	-8682.83
U, KJ/KG	-2372.51	-3482.87	-2374.17	-2374.34	-2376.23	-8950.23	-9771.31
G, KJ/KG	-68015.7	-65484.6	-68012.0	-68011.6	-68007.5	-46036.2	-41316.2
S, KJ/(KG)(K)	20.6101	20.6101	20.6101	20.6101	20.6101	20.6101	20.6101
M, (1/n)	11.545	11.677	11.545	11.545	11.545	12.091	12.095
(dLV/dLP)t	-1.02458	-1.01847	-1.02457	-1.02457	-1.02456	-1.00019	-1.00002
(dLV/dLT)p	1.4518	1.3583	1.4517	1.4517	1.4515	1.0058	1.0007
Cp, KJ/(KG)(K)	10.2015	9.1235	10.2001	10.1999	10.1982	3.7950	3.5262
GAMMAs	1.1419	1.1435	1.1419	1.1419	1.1419	1.2242	1.2426
SON VEL,M/SEC	1647.5	1592.9	1647.4	1647.4	1647.3	1251.8	1163.0
MACH NUMBER	0.000	1.000	0.037	0.039	0.056	3.130	3.584

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

VISC,MILLIPOISE	0.98793	0.94658	0.98787	0.98786	0.98779	0.63871	0.56050

WITH EQUILIBRIUM REACTIONS

Cp, KJ/(KG)(K)	10.2015	9.1235	10.2001	10.1999	10.1982	3.7950	3.5262
CONDUCTIVITY	21.2923	18.3071	21.2881	21.2877	21.2829	3.7435	2.9703
PRANDTL NUMBER	0.4733	0.4717	0.4733	0.4733	0.4733	0.6475	0.6654

WITH FROZEN REACTIONS

Cp, KJ/(KG)(K)	4.1659	4.1259	4.1658	4.1658	4.1657	3.6735	3.5084
CONDUCTIVITY	6.1226	5.7703	6.1220	6.1220	6.1214	3.4483	2.9300
PRANDTL NUMBER	0.6722	0.6768	0.6722	0.6722	0.6722	0.6804	0.6711

PERFORMANCE PARAMETERS

Ae/At	1.0000	16.000	15.239	10.677	9.3320	17.559
CSTAR, M/SEC	2419.7	2419.7	2419.7	2419.7	2419.7	2419.7
CF	0.6583	0.0254	0.0267	0.0381	1.6191	1.7226
Ivac, M/SEC	2985.8	38749.9	36909.9	25883.6	4244.5	4429.4

Isp, M/SEC	1592.9	61.4	64.5	92.1	3917.8	4168.3

MOLE FRACTIONS

*H	0.04856	0.03907	0.04854	0.04854	0.04853	0.00067	0.00008
HO2	0.00001	0.00000	0.00001	0.00001	0.00001	0.00000	0.00000
*H2	0.35175	0.35373	0.35176	0.35176	0.35176	0.36959	0.36996
H2O	0.56137	0.57965	0.56140	0.56140	0.56144	0.62965	0.62995
*O	0.00259	0.00154	0.00258	0.00258	0.00258	0.00000	0.00000
*OH	0.03411	0.02502	0.03410	0.03410	0.03408	0.00010	0.00001
*O2	0.00160	0.00099	0.00160	0.00160	0.00160	0.00000	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

H2O2 O3 H2O(cr) H2O(L)

NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS

THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 290.1 PSIA
CASE =

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
FUEL	H2	1.0000000	53.359	300.000
OXIDANT	O2	1.0000000	0.000	0.000

O/F= 5.00000 %FUEL= 16.666667 R,EQ.RATIO= 1.587337 PHI,EQ.RATIO= 1.587337

	CHAMBER	THROAT	EXIT	EXIT	EXIT	EXIT	EXIT
Pinf/P	1.0000	1.7800	1.0008	1.0009	1.0019	80.549	193.15
P, BAR	20.000	11.236	19.983	19.982	19.963	0.24830	0.10354
T, K	3300.33	2984.73	3299.86	3299.81	3299.27	1445.66	1198.06
RHO, KG/CU M	8.4142-1	5.2270-1	8.4085-1	8.4079-1	8.4013-1	2.3848-2	1.2000-2
H, KJ/KG	4.4116	-1299.69	2.4434	2.2416	-0.01595	-7189.33	-8020.24
U, KJ/KG	-2372.51	-3449.32	-2374.14	-2374.31	-2376.18	-8230.51	-8883.09
G, KJ/KG	-68015.7	-62815.3	-68007.9	-68007.1	-67998.2	-36984.6	-32712.3
S, KJ/(KG)(K)	20.6101	20.6101	20.6101	20.6101	20.6101	20.6101	20.6101
M, (1/n)	11.545	11.545	11.545	11.545	11.545	11.545	11.545
Cp, KJ/(KG)(K)	4.1659	4.0964	4.1658	4.1658	4.1657	3.4435	3.2650
GAMMAs	1.2090	1.2133	1.2090	1.2090	1.2090	1.2645	1.2830
SON VEL,M/SEC	1695.2	1615.0	1695.1	1695.1	1694.9	1147.4	1052.2
MACH NUMBER	0.000	1.000	0.037	0.039	0.056	3.306	3.808

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

VISC,MILLIPOISE	0.98793	0.91824	0.98783	0.98782	0.98770	0.52136	0.44373

WITH FROZEN REACTIONS

Cp, KJ/(KG)(K)	4.1659	4.0964	4.1658	4.1658	4.1657	3.4435	3.2650
CONDUCTIVITY	6.1226	5.5929	6.1218	6.1217	6.1208	2.7750	2.2987
PRANDTL NUMBER	0.6722	0.6725	0.6722	0.6722	0.6722	0.6470	0.6302

PERFORMANCE PARAMETERS

Ae/At	1.0000	16.000	15.239	10.677	9.3320	17.559
CSTAR, M/SEC	2369.2	2369.2	2369.2	2369.2	2369.2	2369.2
CF	0.6816	0.0265	0.0278	0.0397	1.6010	1.6909
Ivac, M/SEC	2946.0	37942.4	36140.8	25345.2	4067.6	4221.5
Isp, M/SEC	1615.0	62.7	65.9	94.1	3793.1	4006.2

MOLE FRACTIONS

*H	0.04856	HO2	0.00001	*H2	0.35175
H2O	0.56137	*O	0.00259	*OH	0.03411
*O2	0.00160				

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

H2O2	O3	H2O(cr)	H2O(L)

NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS