

FileEditor:Sasolwax0907.out

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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  case=LMPHR o/f=2,4,6,8,10,
          rocket frozen nfz=1 tcest,k=3800
          p,bar=20,25,30,
react
  oxid=H2O(L) wt=100
  oxid=CH3OH(L) wt=100
  oxid=NH3(L) wt=100
  fuel=Sasoll Wax 6805 wt=100 t,k=298.16
          h,kj/mol=-1179.851 C 40 H 82

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WARNING!! Wax NOT RECOGNIZED (INPUT)

WARNING!! LITERAL EXPECTED FOR 6805 (INPUT)  
 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=F IONS=F SIUNIT=T DEBUGF=F SHKDBG=F DETDBG=F TRNSPT=F

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

Pc,BAR = 20.000000 25.000000 30.000000

Pc/P =

SUBSONIC AREA RATIOS =

SUPERSONIC AREA RATIOS =

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

REACTANT	WT.FRAC	(ENERGY/R),K	TEMP,K	DENSITY
EXPLODED FORMULA				
O: H2O(L)	0.333333	0.000000E+00	0.00	0.0000
H 2.00000	O 1.00000			
O: CH3OH(L)	0.333333	0.000000E+00	0.00	0.0000
C 1.00000	H 4.00000	O 1.00000		
O: NH3(L)	0.333333	-0.860604E+04	239.72	0.0000
N 1.00000	H 3.00000			
F: Sasoll	1.000000	-0.141903E+06	298.16	0.0000
C 40.00000	H 82.00000			

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                      tpi79 \*CH                      g 4/02 CH2

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g 4/02	CH3	g11/00	CH2OH	g 7/00	CH3O
g 8/99	CH4	g 7/00	CH3OH	srd 01	CH3OOH
g 8/99	*CN	g12/99	CNN	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 9/00	CH3CN	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	CH3N2CH3	g 8/88	C2H5OH
g 7/00	CH3OCH3	srd 01	CH3O2CH3	g 7/00	CCN
tpis91	CNC	srd 01	OCCN	tpis79	C2N2
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
srd 01	CNCOCN	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 6/01	C4N2	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,isoctane	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 6/01	HCN	g 1/01	HCO
tpis89	HCCN	g 6/01	HCCO	g 6/01	HNC
g 7/00	HNCO	g10/01	HNO	tpis89	HNO2
g 5/99	HNO3	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	*N
g 6/01	NCO	g 4/99	*NH	g 3/01	NH2
tpis89	NH3	tpis89	NH2OH	tpis89	*NO
g 4/99	NO2	j12/64	NO3	tpis78	*N2
g 6/01	NCN	g 5/99	N2H2	tpis89	NH2NO2
g 4/99	N2H4	g 4/99	N2O	g 4/99	N2O3
tpis89	N2O4	g 4/99	N2O5	tpis89	N3
g 4/99	N3H	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)		

O/F = 2.000000

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	EFFECTIVE FUEL	EFFECTIVE OXIDANT	MIXTURE
ENTHALPY	h(2)/R	h(1)/R	h0/R
(KG-MOL) (K) /KG	-0.25201194E+03	-0.16844346E+03	-0.19629962E+03
KG-FORM.WT./KG	bi(2)	bi(1)	b0i
*H	0.14562786E+00	0.13733597E+00	0.14009993E+00
*O	0.00000000E+00	0.28905870E-01	0.19270580E-01
*C	0.71037979E-01	0.10403058E-01	0.30614699E-01
*N	0.00000000E+00	0.19572704E-01	0.13048470E-01

POINT	ITN	T	H	O	C	N
1	22	1139.750	-7.809	-35.284	-1.055	-12.332
ADD	C(gr)					
1	3	1137.635	-7.733	-34.919	-1.715	-12.340

## THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 290.1 PSIA  
CASE = LMPHR

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O(L)	0.3333333	0.000	0.000
OXIDANT	CH3OH(L)	0.3333333	0.000	0.000
OXIDANT	NH3(L)	0.3333333	-71555.000	239.720
FUEL	Sasol1	1.0000000	-1179851.000	298.160

O/F= 2.00000 %FUEL= 33.333333 R,EQ.RATIO= 6.812424 PHI,EQ.RATIO=-1.773949

	CHAMBER	THROAT
Pinf/P	1.0000	1.8064
P, BAR	20.000	11.072
T, K	1137.64	1010.49
RHO, KG/CU M	2.7492 0	1.7134 0
H, KJ/KG	-1632.14	-2037.94
U, KJ/KG	-2359.63	-2684.13
G, KJ/KG	-18632.8	-17138.6
S, KJ/(KG) (K)	14.9439	14.9439
M, (1/n)	13.002	13.002
MW, MOL WT	11.863	11.863
Cp, KJ/(KG) (K)	3.2451	3.1374
GAMMAS	1.2454	1.2560
SON VEL,M/SEC	951.9	900.9
MACH NUMBER	0.000	1.000

## PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1295.7

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CF 0.6953  
 Ivac, M/SEC 1618.2  
 Isp, M/SEC 900.9

## MOLE FRACTIONS

CH4	0.13546	*CO	0.12393	*CO2	0.01611
C2H4	0.00001	C2H6	0.00002	HCN	0.00001
*H2	0.48673	H2O	0.07246	NH3	0.00054
*N2	0.07712	C(gr)	0.08762		

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

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

POINT	ITN	T	H	O	C	N
1	3	1153.327	-7.650	-34.547	-1.737	-12.244

## THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 362.6 PSIA  
 CASE = LMPHR

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O(L)	0.3333333	0.000	0.000
OXIDANT	CH3OH(L)	0.3333333	0.000	0.000
OXIDANT	NH3(L)	0.3333333	-71555.000	239.720
FUEL	Sasol1	1.0000000	-1179851.000	298.160

O/F= 2.00000 %FUEL= 33.333333 R,EQ.RATIO= 6.812424 PHI,EQ.RATIO=-1.773949

	CHAMBER	THROAT
Pinf/P	1.0000	1.8044
P, BAR	25.000	13.855
T, K	1153.33	1025.92
RHO, KG/CU M	3.4148 0	2.1275 0
H, KJ/KG	-1632.14	-2040.05
U, KJ/KG	-2364.25	-2691.29
G, KJ/KG	-18703.3	-17225.4
S, KJ/(KG) (K)	14.8017	14.8017

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M, (1/n)	13.098	13.098
MW, MOL WT	12.016	12.016
Cp, KJ/(KG) (K)	3.2554	3.1465
GAMMAS	1.2422	1.2527
SON VEL,M/SEC	953.7	903.2
MACH NUMBER	0.000	1.000

## PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1301.0
CF	0.6943
Ivac, M/SEC	1624.2
Isp, M/SEC	903.2

## MOLE FRACTIONS

CH4	0.14363	*CO	0.12547	*CO2	0.01609
C2H4	0.00001	C2H6	0.00002	HCN	0.00001
*H2	0.47956	H2O	0.07391	NH3	0.00061
*N2	0.07809	C(gr)	0.08261		

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

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

POINT	ITN	T	H	O	C	N
1	3	1166.382	-7.582	-34.244	-1.754	-12.165

## THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 435.1 PSIA  
CASE = LMPHR

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O (L)	0.3333333	0.000	0.000
OXIDANT	CH3OH (L)	0.3333333	0.000	0.000
OXIDANT	NH3 (L)	0.3333333	-71555.000	239.720
FUEL	Sasol1	1.0000000	-1179851.000	298.160

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O/F= 2.00000 %FUEL= 33.33333 R,EQ.RATIO= 6.812424 PHI,EQ.RATIO=-1.773949

	CHAMBER	THROAT
Pinf/P	1.0000	1.8027
P, BAR	30.000	16.642
T, K	1166.38	1038.79
RHO, KG/CU M	4.0769 0	2.5393 0
H, KJ/KG	-1632.14	-2041.73
U, KJ/KG	-2367.99	-2697.08
G, KJ/KG	-18762.0	-17297.7
S, KJ/(KG) (K)	14.6863	14.6863
M, (1/n)	13.179	13.179
MW, MOL WT	12.146	12.146
Cp, KJ/(KG) (K)	3.2643	3.1545
GAMMAS	1.2396	1.2500
SON VEL,M/SEC	955.1	905.1
MACH NUMBER	0.000	1.000

## PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1305.3
CF	0.6934
Ivac, M/SEC	1629.2
Isp, M/SEC	905.1

## MOLE FRACTIONS

CH4	0.15055	*CO	0.12674	*CO2	0.01610
C2H4	0.00001	C2H6	0.00003	HCN	0.00001
*H2	0.47348	H2O	0.07513	NH3	0.00067
*N2	0.07890	C(gr)	0.07837		

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

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

O/F = 4.000000

	EFFECTIVE FUEL	EFFECTIVE OXIDANT	MIXTURE
ENTHALPY	h(2)/R	h(1)/R	h0/R
(KG-MOL) (K) /KG	-0.25201194E+03	-0.16844346E+03	-0.18515716E+03
KG-FORM.WT./KG	bi(2)	bi(1)	b0i
*H	0.14562786E+00	0.13733597E+00	0.13899435E+00

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*O	0.00000000E+00	0.28905870E-01	0.23124696E-01
*C	0.71037979E-01	0.10403058E-01	0.22530042E-01
*N	0.00000000E+00	0.19572704E-01	0.15658164E-01

POINT	ITN	T	H	O	C	N
1	4	1190.307	-7.779	-34.158	-1.787	-12.364

REMOVE	C(gr)	T	H	O	C	N
1	3	1193.955	-7.761	-33.919	-2.100	-12.371

## THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 290.1 PSIA  
CASE = LMPHR

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O (L)	0.3333333	0.000	0.000
OXIDANT	CH3OH (L)	0.3333333	0.000	0.000
OXIDANT	NH3 (L)	0.3333333	-71555.000	239.720
FUEL	Sasol1	1.0000000	-1179851.000	298.160

O/F= 4.00000 %FUEL= 20.000000 R,EQ.RATIO= 4.953893 PHI,EQ.RATIO=-0.886974

	CHAMBER	THROAT
Pinf/P	1.0000	1.8338
P, BAR	20.000	10.906
T, K	1193.95	1040.03
RHO, KG/CU M	2.3444 0	1.4676 0
H, KJ/KG	-1539.49	-2022.89
U, KJ/KG	-2392.60	-2766.02
G, KJ/KG	-20887.3	-18876.4
S, KJ/(KG) (K)	16.2048	16.2048

M, (1/n)	11.636	11.636
MW, MOL WT	11.636	11.636
Cp, KJ/(KG) (K)	3.1916	3.0885
GAMMA <sub>s</sub>	1.2884	1.3010
SON VEL, M/SEC	1048.4	983.3
MACH NUMBER	0.000	1.000

## PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1386.0
CF	0.7094
Ivac, M/SEC	1739.0
Isp, M/SEC	983.3

## MOLE FRACTIONS

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CH4	0.08070	*CO	0.16599	*CO2	0.01544
C2H6	0.00001	HCN	0.00001	*H2	0.57428
H2O	0.07221	NH3	0.00052	*N2	0.09084

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

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

POINT	ITN	T	H	O	C	N
1	3	1211.059	-7.673	-33.530	-2.159	-12.277

## THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 362.6 PSIA

CASE = LMPHR

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O(L)	0.3333333	0.000	0.000
OXIDANT	CH3OH(L)	0.3333333	0.000	0.000
OXIDANT	NH3(L)	0.3333333	-71555.000	239.720
FUEL	Sasoll	1.0000000	-1179851.000	298.160

O/F= 4.00000 %FUEL= 20.000000 R,EQ.RATIO= 4.953893 PHI,EQ.RATIO=-0.886974

	CHAMBER	THROAT
Pinf/P	1.0000	1.8317
P, BAR	25.000	13.648
T, K	1211.06	1056.50
RHO, KG/CU M	2.9057 0	1.8183 0
H, KJ/KG	-1539.49	-2026.46
U, KJ/KG	-2399.88	-2777.04
G, KJ/KG	-20971.9	-18978.9
S, KJ/(KG) (K)	16.0458	16.0458
M, (1/n)	11.703	11.703
MW, MOL WT	11.703	11.703
Cp, KJ/(KG) (K)	3.2023	3.0981
GAMMAS	1.2851	1.2976
SON VEL,M/SEC	1051.5	986.9
MACH NUMBER	0.000	1.000



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## PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1393.2
CF	0.7084
IvaC, M/SEC	1747.4
Isp, M/SEC	986.9

## MOLE FRACTIONS

CH4	0.08399	*CO	0.16423	*CO2	0.01541
C2H4	0.00001	C2H6	0.00001	HCN	0.00002
*H2	0.56884	H2O	0.07558	NH3	0.00059
*N2	0.09132				

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

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

POINT	ITN	T	H	O	C	N
1	3	1225.339	-7.602	-33.215	-2.207	-12.200

## THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 435.1 PSIA  
CASE = LMPHR

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O (L)	0.3333333	0.000	0.000
OXIDANT	CH3OH (L)	0.3333333	0.000	0.000
OXIDANT	NH3 (L)	0.3333333	-71555.000	239.720
FUEL	Sasoll	1.0000000	-1179851.000	298.160

O/F= 4.00000 %FUEL= 20.000000 R,EQ.RATIO= 4.953893 PHI,EQ.RATIO=-0.886974

	CHAMBER	THROAT
Pinf/P	1.0000	1.8300
P, BAR	30.000	16.393
T, K	1225.34	1070.29

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RHO, KG/CU M	3.4628	0	2.1664	0
H, KJ/KG	-1539.49	-2029.35		
U, KJ/KG	-2405.84	-2786.08		
G, KJ/KG	-21042.7	-19064.7		
S, KJ/(KG) (K)	15.9166	15.9166		

M, (1/n)	11.760	11.760
MW, MOL WT	11.760	11.760
Cp, KJ/(KG) (K)	3.2113	3.1062
GAMMAS	1.2823	1.2947
SON VEL,M/SEC	1054.0	989.8
MACH NUMBER	0.000	1.000

## PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1399.1
CF	0.7075
Ivac, M/SEC	1754.3
Isp, M/SEC	989.8

## MOLE FRACTIONS

CH4	0.08677	*CO	0.16274	*CO2	0.01538
C2H4	0.00001	C2H6	0.00001	HCN	0.00002
*H2	0.56425	H2O	0.07844	NH3	0.00066
*N2	0.09173				

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

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

O/F = 6.000000

ENTHALPY (KG-MOL) (K) /KG	EFFECTIVE FUEL h(2) /R	EFFECTIVE OXIDANT h(1) /R	MIXTURE h0/R
	-0.25201194E+03	-0.16844346E+03	-0.18038182E+03

  

KG-FORM.WT./KG	bi(2)	bi(1)	b0i
*H	0.14562786E+00	0.13733597E+00	0.13852052E+00
*O	0.00000000E+00	0.28905870E-01	0.24776460E-01
*C	0.71037979E-01	0.10403058E-01	0.19065190E-01
*N	0.00000000E+00	0.19572704E-01	0.16776604E-01

POINT	ITN	T	H	O	C	N
1	5	1234.653	-7.776	-33.031	-2.754	-12.407

## THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 290.1 PSIA

CASE = LMPHR

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O (L)	0.3333333	0.000	0.000
OXIDANT	CH3OH (L)	0.3333333	0.000	0.000
OXIDANT	NH3 (L)	0.3333333	-71555.000	239.720
FUEL	Sasoll	1.0000000	-1179851.000	298.160

O/F= 6.00000 %FUEL= 14.285714 R,EQ.RATIO= 4.334382 PHI,EQ.RATIO=-0.591316

	CHAMBER	THROAT
Pinf/P	1.0000	1.8456
P, BAR	20.000	10.837
T, K	1234.65	1066.43
RHO, KG/CU M	2.1645 0	1.3578 0
H, KJ/KG	-1499.79	-2026.70
U, KJ/KG	-2423.78	-2824.81
G, KJ/KG	-22134.8	-19850.2
S, KJ/(KG) (K)	16.7132	16.7132
M, (1/n)	11.110	11.110
MW, MOL WT	11.110	11.110
Cp, KJ/(KG) (K)	3.1800	3.0841
GAMMAS	1.3078	1.3204
SON VEL,M/SEC	1099.3	1026.6
MACH NUMBER	0.000	1.000

## PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1434.9
CF	0.7154
Ivac, M/SEC	1804.0
Isp, M/SEC	1026.6

## MOLE FRACTIONS

CH4	0.03699	*CO	0.15990	*CO2	0.01491
HCN	0.00001	*H2	0.60921	H2O	0.08555
NH3	0.00048	*N2	0.09295		

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

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

POINT	ITN	T	H	O	C	N
1	3	1251.607	-7.687	-32.677	-2.789	-12.313

# THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 362.6 PSIA

CASE = LMPHR

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O (L)	0.3333333	0.000	0.000
OXIDANT	CH3OH (L)	0.3333333	0.000	0.000
OXIDANT	NH3 (L)	0.3333333	-71555.000	239.720
FUEL	Sasol1	1.0000000	-1179851.000	298.160

O/F= 6.00000 %FUEL= 14.285714 R,EQ.RATIO= 4.334382 PHI,EQ.RATIO=-0.591316

	CHAMBER	THROAT
Pinf/P	1.0000	1.8436
P, BAR	25.000	13.561
T, K	1251.61	1082.65
RHO, KG/CU M	2.6835 0	1.6827 0
H, KJ/KG	-1499.79	-2030.48
U, KJ/KG	-2431.42	-2836.34
G, KJ/KG	-22209.7	-19944.6
S, KJ/(KG) (K)	16.5466	16.5466
M, (1/n)	11.170	11.170
MW, MOL WT	11.170	11.170
Cp, KJ/(KG) (K)	3.1892	3.0919
GAMMA <sub>s</sub>	1.3045	1.3171
SON VEL, M/SEC	1102.4	1030.2
MACH NUMBER	0.000	1.000

## PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1442.1
CF	0.7144
Ivac, M/SEC	1812.5
Isp, M/SEC	1030.2

## MOLE FRACTIONS

FileEditor:Sasolwax0907.out

CH4	0.03987	*CO	0.15826	*CO2	0.01481
HCN	0.00001	*H2	0.60420	H2O	0.08888
NH3	0.00055	*N2	0.09342		

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

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

POINT	ITN	T	H	O	C	N
1	3	1265.828	-7.615	-32.387	-2.819	-12.236

## THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 435.1 PSIA

CASE = LMPHR

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O (L)	0.3333333	0.000	0.000
OXIDANT	CH3OH (L)	0.3333333	0.000	0.000
OXIDANT	NH3 (L)	0.3333333	-71555.000	239.720
FUEL	Sasol1	1.0000000	-1179851.000	298.160

O/F= 6.00000 %FUEL= 14.285714 R,EQ.RATIO= 4.334382 PHI,EQ.RATIO=-0.591316

	CHAMBER	THROAT
Pinf/P	1.0000	1.8419
P, BAR	30.000	16.288
T, K	1265.83	1096.28
RHO, KG/CU M	3.1986 0	2.0052 0
H, KJ/KG	-1499.79	-2033.57
U, KJ/KG	-2437.70	-2845.86
G, KJ/KG	-22273.6	-20024.9
S, KJ/(KG) (K)	16.4112	16.4112
M, (1/n)	11.221	11.221
MW, MOL WT	11.221	11.221
Cp, KJ/(KG) (K)	3.1970	3.0987
GAMMA <sub>s</sub>	1.3017	1.3143
SON VEL,M/SEC	1104.9	1033.2

FileEditor:Sasolwax0907.out

MACH NUMBER 0.000 1.000

## PERFORMANCE PARAMETERS

Ae/At 1.0000  
 CSTAR, M/SEC 1448.0  
 CF 0.7135  
 Ivac, M/SEC 1819.4  
 Isp, M/SEC 1033.2

## MOLE FRACTIONS

CH4	0.04231	*CO	0.15687	*CO2	0.01473
HCN	0.00002	*H2	0.59994	H2O	0.09170
NH3	0.00061	*N2	0.09381		

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

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

O/F = 8.000000

ENTHALPY (KG-MOL) (K) /KG	EFFECTIVE FUEL h(2) /R	EFFECTIVE OXIDANT h(1) /R	MIXTURE h0/R
	-0.25201194E+03	-0.16844346E+03	-0.17772885E+03

  

KG-FORM.WT./KG	bi(2)	bi(1)	b0i
*H	0.14562786E+00	0.13733597E+00	0.13825729E+00
*O	0.00000000E+00	0.28905870E-01	0.25694107E-01
*C	0.71037979E-01	0.10403058E-01	0.17140272E-01
*N	0.00000000E+00	0.19572704E-01	0.17397959E-01

POINT	ITN	T	H	O	C	N
1	4	1274.629	-7.809	-32.225	-3.344	-12.444

## THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 290.1 PSIA  
 CASE = LMPHR

REACTANT	WT FRACTION	ENERGY	TEMP
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FileEditor:Sasolwax0907.out

		(SEE NOTE)	KJ/KG-MOL	K
OXIDANT	H2O (L)	0.3333333	0.000	0.000
OXIDANT	CH3OH (L)	0.3333333	0.000	0.000
OXIDANT	NH3 (L)	0.3333333	-71555.000	239.720
FUEL	Sasoll	1.0000000	-1179851.000	298.160

O/F= 8.00000 %FUEL= 11.111111 R,EQ.RATIO= 4.024627 PHI,EQ.RATIO=-0.443487

	CHAMBER	THROAT
Pinf/P	1.0000	1.8505
P, BAR	20.000	10.808
T, K	1274.63	1097.10
RHO, KG/CU M	2.0560 0	1.2908 0
H, KJ/KG	-1477.73	-2033.90
U, KJ/KG	-2450.47	-2871.16
G, KJ/KG	-23119.3	-20661.3
S, KJ/(KG) (K)	16.9787	16.9787

M, (1/n)	10.895	10.895
MW, MOL WT	10.895	10.895
Cp, KJ/(KG) (K)	3.1792	3.0860
GAMMAS	1.3159	1.3285
SON VEL,M/SEC	1131.4	1054.7
MACH NUMBER	0.000	1.000

## PERFORMANCE PARAMETERS

Ae/At	1.00000
CSTAR, M/SEC	1469.1
CF	0.7179
Ivac, M/SEC	1848.5
Isp, M/SEC	1054.7

## MOLE FRACTIONS

CH4	0.01712	*CO	0.15522	*CO2	0.01439
HCN	0.00001	*H2	0.62235	H2O	0.09593
NH3	0.00042	*N2	0.09456		

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

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

POINT	ITN	T	H	O	C	N
1	3	1289.865	-7.717	-31.928	-3.340	-12.348

## THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 362.6 PSIA  
CASE = LMPHR

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O (L)	0.3333333	0.000	0.000
OXIDANT	CH3OH (L)	0.3333333	0.000	0.000
OXIDANT	NH3 (L)	0.3333333	-71555.000	239.720
FUEL	Sasol1	1.0000000	-1179851.000	298.160

O/F= 8.00000 %FUEL= 11.111111 R,EQ.RATIO= 4.024627 PHI,EQ.RATIO=-0.443487

	CHAMBER	THROAT
Pinf/P	1.0000	1.8487
P, BAR	25.000	13.523
T, K	1289.87	1111.66
RHO, KG/CU M	2.5519 0	1.6016 0
H, KJ/KG	-1477.73	-2037.33
U, KJ/KG	-2457.41	-2881.66
G, KJ/KG	-23158.8	-20723.0
S, KJ/(KG) (K)	16.8088	16.8088

M, (1/n)	10.947	10.947
MW, MOL WT	10.947	10.947
Cp, KJ/(KG) (K)	3.1870	3.0926
GAMMA <sub>s</sub>	1.3129	1.3255
SON VEL, M/SEC	1134.1	1057.9
MACH NUMBER	0.000	1.000

## PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1475.5
CF	0.7170
Ivac, M/SEC	1856.0
Isp, M/SEC	1057.9

## MOLE FRACTIONS

CH4	0.01955	*CO	0.15378	*CO2	0.01428
HCN	0.00001	*H2	0.61798	H2O	0.09893
NH3	0.00049	*N2	0.09498		

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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



FileEditor:Sasolwax0907.out

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

POINT	ITN	T	H	O	C	N
1	3	1302.868	-7.643	-31.679	-3.341	-12.269

## THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 435.1 PSIA

CASE = LMPHR

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O (L)	0.3333333	0.000	0.000
OXIDANT	CH3OH (L)	0.3333333	0.000	0.000
OXIDANT	NH3 (L)	0.3333333	-71555.000	239.720
FUEL	Sasol1	1.0000000	-1179851.000	298.160

O/F= 8.00000 %FUEL= 11.111111 R,EQ.RATIO= 4.024627 PHI,EQ.RATIO=-0.443487

	CHAMBER	THROAT
Pinf/P	1.0000	1.8472
P, BAR	30.000	16.241
T, K	1302.87	1124.11
RHO, KG/CU M	3.0441 0	1.9101 0
H, KJ/KG	-1477.73	-2040.19
U, KJ/KG	-2463.23	-2890.48
G, KJ/KG	-23197.4	-20779.8
S, KJ/(KG) (K)	16.6706	16.6706
M, (1/n)	10.992	10.992
MW, MOL WT	10.992	10.992
Cp, KJ/(KG) (K)	3.1938	3.0984
GAMMAS	1.3103	1.3230
SON VEL,M/SEC	1136.4	1060.6
MACH NUMBER	0.000	1.000

## PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1480.9
CF	0.7162
Ivac, M/SEC	1862.3
Isp, M/SEC	1060.6

## MOLE FRACTIONS

FileEditor:Sasolwax0907.out

CH4	0.02166	*CO	0.15253	*CO2	0.01420
HCN	0.00002	*H2	0.61421	H2O	0.10150
NH3	0.00055	*N2	0.09534		

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

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

O/F = 10.000000

	EFFECTIVE FUEL	EFFECTIVE OXIDANT	MIXTURE
ENTHALPY	h(2)/R	h(1)/R	h0/R
(KG-MOL) (K) /KG	-0.25201194E+03	-0.16844346E+03	-0.17604060E+03
KG-FORM.WT./KG	bi(2)	bi(1)	b0i
*H	0.14562786E+00	0.13733597E+00	0.13808978E+00
*O	0.00000000E+00	0.28905870E-01	0.26278064E-01
*C	0.71037979E-01	0.10403058E-01	0.15915324E-01
*N	0.00000000E+00	0.19572704E-01	0.17793368E-01

POINT	ITN	T	H	O	C	N
1	4	1317.779	-7.853	-31.412	-3.943	-12.485

## THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 290.1 PSIA  
CASE = LMPHR

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O (L)	0.3333333	0.000	0.000
OXIDANT	CH3OH (L)	0.3333333	0.000	0.000
OXIDANT	NH3 (L)	0.3333333	-71555.000	239.720
FUEL	Sasol1	1.0000000	-1179851.000	298.160

O/F= 10.00000 %FUEL= 9.090909 R,EQ.RATIO= 3.838774 PHI,EQ.RATIO=-0.354790

	CHAMBER	THROAT
Pinf/P	1.0000	1.8518
P, BAR	20.000	10.801
T, K	1317.78	1133.27

FileEditor:Sasolwax0907.out

RHO, KG/CU M	1.9751	0	1.2403	0
H, KJ/KG	-1463.69	-2043.02		
U, KJ/KG	-2476.27	-2913.82		
G, KJ/KG	-24046.9	-21464.2		
S, KJ/(KG) (K)	17.1374	17.1374		

M, (1/n)	10.821	10.821
MW, MOL WT	10.821	10.821
Cp, KJ/(KG) (K)	3.1859	3.0930
GAMMAS	1.3179	1.3306
SON VEL,M/SEC	1155.2	1076.4
MACH NUMBER	0.000	1.000

## PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1498.1
CF	0.7185
Ivac, M/SEC	1885.4
Isp, M/SEC	1076.4

## MOLE FRACTIONS

CH4	0.00761	*CO	0.15070	*CO2	0.01390
HCN	0.00001	*H2	0.62550	H2O	0.10585
NH3	0.00036	*N2	0.09608		

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

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

POINT	ITN	T	H	O	C	N
1	3	1329.614	-7.756	-31.196	-3.880	-12.385

## THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 362.6 PSIA

CASE = LMPHR

REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
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FileEditor:Sasolwax0907.out

OXIDANT	H2O(L)	0.3333333	0.000	0.000
OXIDANT	CH3OH(L)	0.3333333	0.000	0.000
OXIDANT	NH3(L)	0.3333333	-71555.000	239.720
FUEL	Sasol1	1.0000000	-1179851.000	298.160

O/F= 10.00000 %FUEL= 9.090909 R,EQ.RATIO= 3.838774 PHI,EQ.RATIO=-0.354790

	CHAMBER	THROAT
Pinf/P	1.0000	1.8503
P, BAR	25.000	13.511
T, K	1329.61	1144.60
RHO, KG/CU M	2.4560 0	1.5419 0
H, KJ/KG	-1463.69	-2045.63
U, KJ/KG	-2481.60	-2921.90
G, KJ/KG	-24022.2	-21465.2
S, KJ/(KG) (K)	16.9662	16.9662

M, (1/n)	10.861	10.861
MW, MOL WT	10.861	10.861
Cp, KJ/(KG) (K)	3.1919	3.0981
GAMMA <sub>s</sub>	1.3155	1.3282
SON VEL,M/SEC	1157.2	1078.8
MACH NUMBER	0.000	1.000

## PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1502.9
CF	0.7178
IvaC, M/SEC	1891.1
Isp, M/SEC	1078.8

## MOLE FRACTIONS

CH4	0.00945	*CO	0.14957	*CO2	0.01381
HCN	0.00001	*H2	0.62213	H2O	0.10820
NH3	0.00042	*N2	0.09641		

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

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

POINT	ITN	T	H	O	C	N
1	3	1340.206	-7.679	-31.006	-3.840	-12.304

THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 435.1 PSIA  
CASE = LMPHR

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O (L)	0.3333333	0.000	0.000
OXIDANT	CH3OH (L)	0.3333333	0.000	0.000
OXIDANT	NH3 (L)	0.3333333	-71555.000	239.720
FUEL	Sasol1	1.0000000	-1179851.000	298.160

O/F= 10.00000 %FUEL= 9.090909 R,EQ.RATIO= 3.838774 PHI,EQ.RATIO=-0.354790

	CHAMBER	THROAT
Pinf/P	1.0000	1.8491
P, BAR	30.000	16.224
T, K	1340.21	1154.76
RHO, KG/CU M	2.9337 0	1.8413 0
H, KJ/KG	-1463.69	-2047.92
U, KJ/KG	-2486.30	-2929.04
G, KJ/KG	-24015.2	-21479.0
S, KJ/(KG) (K)	16.8269	16.8269
M, (1/n)	10.897	10.897
MW, MOL WT	10.897	10.897
Cp, KJ/(KG) (K)	3.1973	3.1027
GAMMA <sub>s</sub>	1.3135	1.3261
SON VEL,M/SEC	1158.9	1081.0
MACH NUMBER	0.000	1.000

PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1507.2
CF	0.7172
Ivac, M/SEC	1896.1
Isp, M/SEC	1081.0

MOLE FRACTIONS

CH4	0.01112	*CO	0.14855	*CO2	0.01374
HCN	0.00001	*H2	0.61909	H2O	0.11031
NH3	0.00048	*N2	0.09670		

\* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

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

