16-CHEM-A1, PROCESS BALANCES and CHEMICAL THERMODYNAMICS

MAY 2018

Three Hours Duration

NOTES:

1) If doubt exists as to the interpretation of any question, you are urged to submit a clear statement of any assumptions made along with the answer paper.
2) Property data required to solve a given problem are provided in the problem statement or are available in the recommended texts. If you are unable to locate the required data, do not let this prevent you from solving the rest of the problem. Even in the absence of property data, you still have the opportunity to provide a solution methodology.
3) This is an open-book exam.
4) Any non-communicating calculator is permitted.
5) The examination is in two parts – Part A (Questions 1 to 3): Process Balances
   Part B (Questions 4 and 6): Chemical Thermodynamics
6) Answer **TWO** questions from Part A and **TWO** questions from Part B.
7) **FOUR** questions constitute a complete paper.
8) Each question is of equal value.

PART A: PROCESS MASS and ENERGY BALANCES

1) Propane (C_3H_8) is burned with excess air to ensure complete combustion. 55 kg of carbon dioxide (CO_2) and 15 kg of carbon monoxide (CO) are obtained when propane is completely burned with 500 kg of air. Determine the following:

   (a) The mass of propane burnt in kg.
   (b) The percent of excess air.
   (c) The molar composition of flue gas.

2) Air at 320 K saturated with water vapor is dehumidified by cooling to 285 K and by condensation of water vapor. Air leaving the dehumidifier saturated at 285 K is mixed with a part of the original air, which has bypassed the dehumidifier. The resulting air stream is reheated to 320 K. It is desired that the final air contain water vapor not exceeding 0.03 kg/kg of dry air. Calculate:

   (a) The dry air bypassed (in kg) per each kg of dry air sent through the dehumidifier.
   (b) The water vapor condensed in the dehumidifier (in kg) per 100 m^3 of air sent through it.
   (c) The volume of final air obtained per 100 m^3 of air passed though the dehumidifier.

   DATA: Total pressure of system = 1 atm or 101.3 kPa
   Vapor pressure of water at 285 K = 1.4 kPa Vapor pressure of water at 320 K = 10.6 kPa

3) Ammonium sulfate ($(NH_4)_2SO_4$) is dried from 4.0% to 0.2% moisture in a countercurrent rotary drier. Hot air at 363 K and containing 0.01 kg/kg dry air is admitted at one end of the drier feed, flows countercurrently in contact with the solids, and leaves at the other end of the drier at 305 K. The solid enters at 298 K and leaves at 333 K. The heat loss from the drier is estimated to be 4×10^4 kJ/hr. Estimate the air requirement for the drier (in kg/hr) for producing ammonium sulfate at the rate of 1000 kg/hr.

   DATA: Latent heat of vaporization of water at 273 K = 2502.3 kJ/kg
   Heat capacity of dry air = 1.005 kJ/kg.K Heat capacity of water vapor = 1.884 kJ/kg.K
   Heat capacity of water = 4.2 kJ/kg.K Heat capacity of dry $(NH_4)_2SO_4$ = 1.507 kJ/kg.K

PART B: CHEMICAL THERMODYNAMICS

4) A gas mixture at 500 °R and 200 psia contains 80% hydrochloric acid (HCl) and 20% dichloromethane (DCM) on a molar basis. Calculate the fugacity coefficients of HCl and DCM at this temperature and pressure.

DATA:
Critical temperature of HCl = 584 °R
Critical temperature of DCM = 933 °R
Critical pressure of HCl = 1209.6 psia
Critical pressure of DCM = 893 psia

5) Calculate the standard Gibbs free energy change (ΔG^{o}) for the following ethanol decomposition reaction at 443 K using the attached heat capacity table:

$$CH_3CH_2OH \rightarrow CH_2{=}CH_2 + H_2O$$

DATA:
Standard enthalpy of the reaction at 298 K (ΔH^{o}_{298}) = 44.843 kJ/mole
Standard Gibbs free energy of formation of ethanol at 298 K ($\Delta G^{o}_{f,298}$) = -168.16 kJ/mole
Standard Gibbs free energy of formation of ethylene at 298 K ($\Delta G^{o}_{f,298}$) = 68.06 kJ/mole
Standard Gibbs free energy of formation of water at 298 K ($\Delta G^{o}_{f,298}$) = -228.37 kJ/mole

6) The volume occupied by of one mole of nitrogen gas at 400 K is one liter. Find the change in Gibbs free energy (ΔG) and entropy (ΔS) when the volume is increased to 2 liters (isothermal expansion) for the following cases:

a) Nitrogen behaves as an ideal gas.
b) Nitrogen behaves as van der Waals gas.

The van der Waals constants for nitrogen are:

$a = 1.39\ l^2.atm/mole^2$ $\qquad$ $b = 39.1\ cm^3/mole.$

TABLE C-4 Heat Capacity of Gas

$C_p = A + BT + CT^2 + DT^3 + ET^4$						(C_p–joule/(mol K), T–K)			
No.	Formula	Substance	A	B	C	D	E	T_{min}	T_{max}
1	$C_2H_3C_{13}$	1,1,1-Trichloroethane	18.674	3.3443E-01	-3.4963E-04	1.8764E-07	-4.0744E-11	100	1500
2	$C_2H_3C_{13}$	1,1,2-Trichloroethane	28.881	2.4893E-01	-1.7639E-04	5.2632E-08	-3.5668E-12	200	1500
3	$C_2H_4C_{12}$	1,1-Dichloroethane	15.730	2.6124E-01	-2.1489E-04	9.5761E-08	-1.8004E-11	200	1500
4	$C_2H_4C_{12}$	1,2-Dichloroethane	37.275	1.4362E-01	1.0378E-05	-7.8305E-08	2.8872E-11	200	1500
5	C_4H_6	1,3-Butadiene	18.835	2.0473E-01	6.2485E-05	-1.7148E-07	6.0858E-11	100	1500
6	$C_4H_8O_2$	1,4-Dioxane	-46.223	5.7263E-01	-3.8800E-04	1.1392E-07	-9.0669E-12	298	1500
7	$C_4H_{10}O$	1-Butanol (*n*-Butanol)	8.157	4.1032E-01	-2.2645E-04	6.0372E-08	-6.2802E-12	200	2980
8	C_4H_8	1-Butene	24.915	2.0648E-01	5.9828E-05	-1.4166E-07	4.7053E-11	200	1500
9	$C_{10}H_{20}$	1-Decene	121.553	2.0974E-01	7.8760E-04	-8.6982E-07	2.6033E-10	150	1500
10	C_9H_{10}	1-Nonane (*n*-Nonane)	29.687	6.6821E-01	-9.6492E-05	-2.0014E-07	8.2200E-11	200	1500
11	C_8H_{16}	1-Octene	56.266	4.0665E-01	1.5805E-04	-3.2277E-07	1.0600E-10	200	1500
12	C_3H_8O	1-Propanol (*n*-Propanol)	31.507	2.3082E-01	-7.8983E-05	6.3696E-09	8.6908E-13	100	2980
13	C_2H_4O	Acetaldehyde	34.140	4.0020E-02	1.5634E-04	-1.6445E-07	4.7248E-11	100	1500
14	$C_2H_4O_2$	Acetic acid	34.850	3.7626E-02	2.8311E-04	-3.0767E-07	9.2646E-11	50	1500
15	$C_4H_6O_3$	Acetic anhydride	9.500	3.4425E-01	-8.6736E-05	-7.6769E-08	3.6721E-11	200	1500
16	C_3H_6O	Acetone	35.918	9.3896E-02	1.8730E-04	-2.1643E-07	6.3174E-11	100	1500
17	$C_3H_4O_2$	Acrylic acid	7.755	2.9386E-01	-2.0878E-04	7.1591E-08	-9.0960E-12	250	1500
18	NH_3	Ammonia	33.573	-1.2581E-02	8.8906E-05	-7.1783E-08	1.8569E-11	100	1500
19	C_6H_7N	Aniline	-22.062	5.7313E-01	-4.5651E-04	1.8410E-07	-2.9867E-11	200	1500
20	C_6H_6	Benzene	-31.368	4.7460E-01	-3.1137E-04	8.5237E-08	-5.0524E-12	200	1500
21	$C_4H_8O_2$	Butyric acid	14.368	3.9591E-01	-1.8906E-04	-7.6462E-09	2.0812E-11	298	1200
22	CS_2	Carbon disulfide	20.461	1.2299E-01	-1.6184E-04	1.0199E-07	-2.4444E-11	100	1500
23	CO_2	Carbon dioxide	27.437	4.2315E-02	-1.9555E-05	3.9968E-09	-2.9872E-13	50	5000
24	CO	Carbon monoxide	29.556	-6.5807E-03	2.0130E-05	-1.2227E-08	2.2617E-12	60	1500
25	CCl_4	Carbon tetrachloride	19.816	3.3311E-01	-5.0511E-04	3.4057E-07	-8.4249E-11	100	1500
26	Cl_2	Chlorine	27.213	3.0426E-02	-3.3353E-05	1.5961E-08	-2.7021E-12	50	1500
27	$CHCl_3$	Chloroform	22.487	1.9823E-01	-2.1676E-04	1.1636E-07	-2.4555E-11	100	1500
28	C_6H_{12}	Cyclohexane	13.783	2.0742E-01	5.3682E-04	-6.3012E-07	1.8988E-10	100	1500
29	$C_6H_{12}O$	Cyclohexanol	17.124	3.3700E-01	2.8176E-04	-4.2713E-07	1.3215E-10	200	1500
30	C_3H_6	Cyclopropane	21.172	6.3106E-02	2.9197E-04	-3.2708E-07	9.9730E-11	100	1500
31	CH_2Cl_2	Dichloromethane	26.694	8.3984E-02	8.9712E-06	-5.0924E-08	1.8726E-11	100	1500
32	$C_4H_{10}O$	Diethyl ether	35.979	2.8444E-01	-1.2673E-06	-1.0128E-07	3.4529E-11	200	1500
33	$C_5H_{10}O$	Diethyl ketone	49.800	2.6897E-01	5.0669E-05	-1.5227E-07	4.9510E-11	200	1500
34	C_2H_7N	Dimethylamine	30.638	1.0737E-01	1.5824E-04	-1.9418E-07	5.8509E-11	200	1500
35	C_2H_6	Ethane	28.146	4.3447E-02	1.8946E-04	-1.9082E-07	5.3349E-11	100	1500
36	C_2H_6O	Ethanol	27.091	1.1055E-01	1.0957E-04	-1.5046E-07	4.6601E-11	100	1500
37	$C_4H_8O_2$	Ethyl acetate	69.848	8.2338E-02	3.7159E-04	-4.1129E-07	1.2369E-10	200	1500
38	C_2H_5Cl	Ethyl chloride	35.946	5.2294E-02	2.0321E-04	-2.2795E-07	6.9123E-11	100	1500
39	C_8H_{10}	Ethylbenzene	-20.527	5.9578E-01	-3.0849E-04	3.5621E-08	1.2409E-11	200	1500
40	C_2H_4	Ethylene	32.083	-1.4831E-02	2.4774E-04	-2.3766E-07	6.8274E-11	60	1500
41	$C_2H_6O_2$	Ethylene glycol	48.218	1.9073E-01	-6.6117E-08	-1.8834E-08	1.2555E-11	200	1500
42	C_2H_4O	Ethylene oxide	30.827	-7.6041E-03	3.2347E-04	-3.2747E-07	9.7271E-11	50	1500
43	F_2	Fluorine	27.408	1.2928E-02	7.0701E-06	-1.6302E-08	5.9789E-12	100	1500
44	$C_3H_8O_3$	Glycerol	9.656	4.2826E-01	-2.6797E-04	3.1794E-08	2.7745E-11	298	1200
45	H_2	Hydrogen	25.399	2.0178E-02	-3.8549E-05	3.1880E-08	-8.7585E-12	250	1500
46	HCl	Hydrogen chloride	29.244	-1.2615E-03	1.1210E-06	4.9676E-09	-2.4963E-12	50	1500
47	CHN	Hydrogen cyanide	25.766	3.7969E-02	-1.2416E-05	-3.2240E-09	2.2610E-12	100	1500
48	H_2O_2	Hydrogen peroxide	36.181	8.2657E-03	6.6420E-05	-6.9944E-08	2.0951E-11	100	1500
49	C_4H_{10}	*i*-Butane (iso-Butane)	6.772	3.1447E-01	-1.0271E-04	-3.6849E-08	2.0429E-11	200	1500
50	CH_4	Methane	34.942	-3.9957E-02	1.9184E-04	-1.5303E-07	3.9321E-11	50	1500
51	CH_4O	Methanol	40.046	-3.8287E-02	2.4529E-04	-2.1679E-07	5.9909E-11	100	1500

TABLE C-4—(continued)

			$C_p = A + BT + CT^2 + DT^3 + ET^4$			(C_p–joule/(mol K), T–K)			
No.	Formula	Substance	A	B	C	D	E	T_{min}	T_{max}
52	CH_3Br	Methyl bromide	29.146	2.4374E–02	1.0655E–04	–1.1324E–07	3.3241E–11	100	1500
53	$C_6H_{12}O$	Methyl isobutyl ketone	2.404	5.8495E–01	–3.7647E–04	1.2418E–07	–1.7051E–11	298	1500
54	CH_5N	Methylamine	40.039	–1.5108E–02	2.5012E–04	–2.3336E–07	6.5582E–11	100	1500
55	C_8H_{10}	*m*-Xylene	–16.725	5.6424E–01	–2.6465E–04	1.3381E–08	1.5869E–11	200	1500
56	$C_{10}H_8$	Naphthalene	67.099	4.3239E–02	9.1740E–04	–1.0019E–06	3.0896E–10	50	1500
57	C_4H_{10}	*n*-Butane	20.056	2.8153E–01	–1.3143E–05	–9.4571E–08	3.4149E–11	200	1500
58	$C_{10}H_{22}$	*n*-Decane	31.780	7.4489E–01	–1.0945E–04	–2.2668E–07	9.3458E–11	200	1500
59	C_7H_{16}	*n*-Heptane	26.984	5.0387E–01	–4.4748E–05	–1.6835E–07	6.5183E–11	200	1500
60	C_6H_{14}	*n*-Hexane	25.924	4.1927E–01	–1.2491E–05	–1.55916E–07	5.8784E–11	200	1500
61	$C_6H_5NO_2$	Nitrobenzene	-16.202	5.6182E–01	–3.9302E–04	1.0043E–07	–1.2252E–12	200	1500
62	N_2	Nitrogen	29.342	–3.5395E–03	1.0076E–05	–4.3116E–09	2.5935E–13	50	1500
63	C_9H_{20}	*n*-Nonane	29.687	6.6821E–01	–9.6492E–05	–2.0014E–07	8.2200E–11	200	1500
64	C_8H_{18}	*n*-Octane	29.053	5.8016E–01	–5.7103E–05	–1.9548E–07	7.6614E–11	200	1500
65	C_5H_{12}	*n*-Pentane	26.671	3.2324E–01	4.2820E–05	–1.6639E–07	5.6036E–11	200	1500
66	O_2	Oxygen	29.526	–8.8999E–03	3.8083E–05	–3.2629E–08	8.8607E–12	50	1500
67	C_8H_{10}	*o*-Xylene	0.182	5.1344E–01	–2.0212E–04	–2.1615E–08	2.3212E–11	200	1500
68	C_6H_6O	Phenol	4.408	3.6338E–01	–6.0417E–05	–1.2794E–07	5.5287E–11	100	1500
69	C_8H_{10}	*p*-Xylene	–17.360	5.6470E–01	–2.6293E–04	1.1217E–08	1.6544E–11	200	1500
70	C_5H_5N	Pyridine	23.262	1.1251E–01	3.7351E–04	–4.5402E–07	1.4286E–10	50	1500
71	C_8H_8	Styrene	71.201	5.4767E–02	6.4793E–04	–6.9875E–07	2.1232E–10	100	1500
72	SO_2	Sulfur dioxide	29.637	3.4735E–02	9.2903E–06	–2.9885E–08	1.0937E–11	100	1500
73	C_7H_8	Toluene	–24.097	5.2187E–01	–2.9827E–04	6.1220E–08	1.2576E–12	200	1500
74	$C_4H_6O_2$	Vinyl acetate	27.664	2.3366E–01	6.2106E–05	–1.6972E–07	5.7917E–11	100	1500
75	H_2O	Water	33.933	–8.4186E–03	2.9906E–05	–1.7825E–08	3.6934E–12	100	1500

C_p – heat capacity of ideal gas, joule/(mol K)

A, B, C, D, and E – regression coefficients for chemical compound

T – temperature, K

T_{min} – minimum temperature, K

T_{max} – maximum temperature, K

TABLE C-5 Heat Capacity of Liquids

			$C_p = A + BT + CT^2 + DT^3$						
No.	Formula	Substance	A	B	C	D	T_{min}	T_{max}	C_p at 25° C
1	$C_2H_3Cl_3$	1,1,1-Trichloroethane	11.142	1.0501E+00	−3.0826E−03	3.5983E−06	244	491	145.56
2	$C_2H_3Cl_3$	1,1,2-Trichloroethane	34.934	8.5054E−01	−2.3306E−03	2.6455E−06	238	542	151.46
3	$C_2H_4Cl_2$	1,1-Dichloroethane	57.325	5.6014E−01	−1.8136E−03	2.5617E−06	177	471	131.00
4	$C_2H_4Cl_2$	1,2-Dichloroethane	26.310	7.7555E−01	−2.2271E−03	2.6107E−06	238	505	128.77
5	C_4H_6	1,3-Butadiene	34.680	7.3205E−01	−2.8426E−03	4.6035E−06	165	383	122.26
6	$C_4H_8O_2$	1,4-Dioxane	−20.729	1.2913E+00	−3.5408E−03	3.5408E−06	286	528	153.23
7	$C_4H_{10}O$	1-Butanol (*n*-Butanol)	83.877	5.6628E−01	−1.7208E−03	2.2780E−06	185	507	160.12
8	C_4H_8	1-Butene	74.597	3.3434E−04	−1.3914E−03	3.0241E−06	89	378	130.74
9	$C_{10}H_{20}$	1-Decene	137.962	1.1934E+00	−3.2863E−03	3.9390E−06	208	555	306.05
10	C_9H_{20}	1-Nonane (*n*-Nonane)	98.040	1.3538E+00	−3.8058E−03	4.4991E−06	221	536	282.60
11	C_8H_{16}	1-Octene	119.984	8.3332E−01	−2.5321E−03	3.4745E−06	172	510	235.43
12	C_3H_8O	1-Propanol (*n*-Propanol)	88.080	4.0224E−01	−1.3032E−03	1.9677E−06	148	483	144.32
13	C_2H_4O	Acetaldehyde	45.056	4.4853E−01	−1.6607E−03	2.7000E−06	151	415	102.72
14	$C_2H_4O_2$	Acetic acid	−18.944	1.0971E+00	2.8921E−03	2.9275E−06	291	533	128.66
15	$C_4H_6O_3$	Acetic anhydride	71.831	8.8879E−01	−2.6534E−03	3.3501E−06	201	512	189.75
16	C_3H_6O	Acetone	46.878	6.2652E−01	−2.0761E−03	2.9583E−06	179	457	127.53
17	$C_3H_4O_2$	Acrylic acid	−18.242	1.2106E+00	−3.1160E−03	3.1409E−06	241	617	123.05
18	NH_3	Ammonia	−182.157	3.3618E+00	−1.4398E−02	2.0371E−05	195	385	80.16
19	C_6H_7N	Aniline	63.288	9.8960E−01	−2.3583E−03	2.3296E−06	268	629	210.44
20	C_6H_6	Benzene	−31.663	1.3043E+00	−3.6078E−03	3.8243E−06	280	506	137.87
21	$C_4H_8O_2$	Butyric acid	28.210	1.1040E+00	−2.8523E−03	2.9528E−06	269	565	182.09
22	CS_2	Carbon disulfide	39.938	2.3565E−01	−7.2098E−04	1.0443E−06	163	497	73.79
23	CO_2	Carbon dioxide	−338.956	5.2796E+00	−2.3279E−02	3.5980E−05	218	274	–
24	CO	Carbon monoxide	−19.312	2.5072E+00	−2.8970E−02	1.2745E−04	69	120	–
25	CCl_4	Carbon tetrachloride	9.671	9.3363E−01	−2.6768E−03	3.0425E−06	251	501	130.72
26	Cl_2	Chlorine	127.601	−6.0215E−01	1.5776E−03	−5.3099E−07	172	396	74.23
27	$CHCl_3$	Chloroform	28.296	6.5897E−01	−2.0353E−03	2.5901E−06	211	483	112.49
28	C_6H_{12}	Cyclohexane	−44.417	1.6016E+00	−4.4676E−03	4.7582E−06	281	498	162.07
29	$C_6H_{12}O$	Cyclohexanol	−47.321	1.9131E+00	−4.8388E−03	4.7281E−06	298	563	218.25
30	C_3H_6	Cyclopropane	30.543	5.0198E−01	−2.1040E−03	3.7444E−06	147	358	92.42
31	CH_2Cl_2	Dichloromethane	38.941	4.9008E−01	−1.6224E−03	2.3069E−06	179	459	101.98
32	$C_4H_{10}O$	Diethyl ether	75.939	7.7335E−01	−2.7936E−03	4.4383E−06	158	420	175.81
33	$C_5H_{10}O$	Diethyl ketone	26.231	1.2822E+00	−3.7449E−03	4.3816E−06	235	505	191.76
34	C_2H_7N	Dimethylamine	36.962	9.5817E−01	−3.5846E−03	5.3990E−06	182	394	147.08
35	C_2H_6	Ethane	38.332	4.1006E−01	−2.3024E−03	5.9347E−06	91	275	–
36	C_2H_6O	Ethanol	59.342	3.6358E−01	−1.2164E−03	1.8030E−06	160	465	107.40
37	$C_4H_8O_2$	Ethyl acetate	62.832	8.4097E−01	−2.6998E−03	3.6631E−06	191	471	170.66
38	C_2H_5Cl	Ethyl chloride	60.180	3.4553E−01	−1.2983E−03	2.1963E−06	138	414	106.00
39	C_8H_{10}	Ethylbenzene	102.11	5.5959E−01	−1.5609E−03	2.0149E−06	179	555	183.60
40	C_2H_4	Ethylene	25.597	5.7078E−01	−3.3620E−03	8.4120E−06	105	254	–
41	$C_2H_6O_2$	Ethylene glycol	75.878	6.4182E−01	−1.6493E−03	1.6937E−06	261	581	165.52
42	C_2H_4O	Ethylene oxide	35.720	4.2908E−01	−1.5473E−03	2.4070E−06	162	422	89.90
43	F_2	Fluorine	83.829	−7.8518E−01	5.2305E−03	4.6617E−06	53	137	–
44	$C_3H_8O_3$	Glycerol	132.145	8.6007E−01	−1.9745E−03	1.8068E−06	292	651	260.94
45	H_2	Hydrogen	50.607	−6.1136E+00	3.0930E−01	−4.1480E−03	14	32	–
46	HCl	Hydrogen chloride	73.993	−1.2946E−01	−7.8980E−05	2.6409E−06	165	308	98.37
47	CHN	Hydrogen cyanide	−123.155	1.7769E+00	−5.8083E−03	6.9129E−06	261	411	73.52
48	H_2O_2	Hydrogen peroxide	−15.248	6.7693E−01	−1.4948E−03	1.2018E−06	273	694	85.55
49	C_4H_{10}	*i*-Butane (*iso*-Butane)	71.791	4.8472E−01	−2.0519E−03	4.0634E−06	115	367	141.61
50	CH_4	Methane	−0.018	1.1982E+00	−9.8722E−03	3.1670E−05	92	172	–
51	CH_3OH	Methanol	40.152	3.1046E−01	−1.0291E−03	1.4598E−06	176	461	79.93

TABLE C-5—(continued)

$C_p = A + BT + CT^2 + DT^3$									
No.	Formula	Substance	A	B	C	D	T_{min}	T_{max}	C_p at 25° C
52	CH_3Br	Methyl bromide	25.042	4.9312E–01	–1.7627E–03	2.5993E–06	181	420	85.16
53	CH_3Cl	Methyl chloride	11.381	6.2328E–01	–2.4353E–03	3.8333E–06	176	375	82.33
54	$C_6H_{12}O$	Methyl isobutyl ketone	96.184	8.5227E–01	–2.5379E–03	3.3066E–06	190	514	212.42
55	CH_5N	Methylamine	13.565	9.0836E–01	–3.4881E–03	5.2770E–06	181	3887	114.19
56	C_8H_{10}	*m*-Xylene	70.916	8.0450E–01	–2.1885E–03	2.5061E–06	226	555	182.66
57	$C_{10}H_8$	Naphthalene	–30.842	1.5362E+00	–3.2492E–03	2.6568E–06	354	674	–
58	C_4H_{10}	*n*-Butane	62.873	5.8913E–01	–2.3588E–03	4.2257E–06	136	383	140.84
59	$C_{10}H_{22}$	*n*-Decane	79.741	1.6926E+00	–4.5287E–03	4.9769E–06	244	557	313.73
60	C_7H_{16}	*n*-Heptane	101.121	9.7739E–01	–3.0712E–03	4.1844E–06	184	486	230.42
61	C_6H_{14}	*n*-Hexane	78.848	8.8729E–01	–2.9482E–03	4.1999E–06	179	457	192.63
62	$C_6H_5NO_2$	Nitrobenzene	51.773	9.1277E–01	–2.1098E–03	2.0093E–06	280	647	189.62
63	N_2	Nitrogen	76.452	–3.5226E–01	–2.6690E–03	5.0057E–05	64	120	–
64	C_9H_{20}	*n*-Nonane	98.040	1.3538E+00	–3.8058E–03	4.4991E–06	221	536	282.60
65	C_8H_{18}	*n*-Octane	82.736	1.3043E+00	–3.8254E–03	4.6459E–06	217	512	254.71
66	C_5H_{12}	*n*-Pentane	80.641	6.2195E–01	–2.2682E–03	3.7423E–06	144	423	163.64
67	O_2	Oxygen	46.432	3.9506E–01	–7.0522E–03	3.9897E–05	54	147	–
68	C_8H_{10}	*o*-Xylene	56.460	9.4926E–01	–2.4902E–03	2.6838E–06	249	567	189.25
69	C_6H_6O	Phenol	38.622	1.0983E+00	–2.4897E–03	2.2802E–06	315	625	–
70	C_8H_{10}	*p*-Xylene	–11.035	1.5158E+00	–3.9039E–03	3.9193E–06	287	555	197.75
71	C_5H_5N	Pyridine	37.150	6.9497E–01	–1.8749E–03	2.1188E–06	233	558	133.85
72	C_8H_8	Styrene	66.737	8.4051E–01	–2.1615E–03	2.3324E–06	244	583	187.00
73	SO_2	Sulfur dioxide	203.445	–1.0537E+00	2.6113E–03	–1.0697E–06	198	409	93.06
74	C_7H_8	Toluene	83.703	5.1666E–01	–1.4910E–03	1.9725E–06	179	533	157.49
75	$C_4H_6O_2$	Vinyl acetate	63.910	7.0656E–01	–2.2832E–03	3.1788E–06	181	472	155.86
76	H_2O	Water	92.053	–3.9953E–02	–2.1103E–04	5.3469E–07	273	615	75.55

C_p – heat capacity of liquid, J/(mol K)

A, B, C, and D – regression coefficients for chemical compound

T – temperature, K

T_{min} – minimum temperature, K

T_{max} – maximum temperature, K

The Periodic Table of the Elements