
UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang Akademik 2004/2005

Oktober 2004

EKC 483 – Kejuruteraan Pemprosesan Petroleum & Gas

Masa : 3 jam

Sila pastikan bahawa kertas peperiksaan ini mengandungi TUJUH muka surat yang bercetak dan TUJUH muka surat Lampiran sebelum anda memulakan peperiksaan ini.

Arahan: Jawab **EMPAT (4)** soalan. Jawab soalan 1 yang **DIWAJIBKAN** dari Bahagian A. Jawab mana-mana **SATU (1)** soalan dari Bahagian B. Jawab mana-mana **DUA (2)** soalan dari Bahagian C.

Pelajar boleh menjawab semua soalan dalam Bahasa Malaysia. Jika pelajar ingin menjawab dalam Bahasa Inggeris, pelajar hendaklah menjawab sekurang-kurangnya SATU soalan dalam Bahasa Malaysia.

Bahagian A - Jawab Soalan 1 yang **DIWAJIBKAN**.
Section A - Answer Question 1 which is **COMPULSORY**.

1. [a] Takrifkan sebutan-sebutan berikut (secara ringkas)

- [i] Penyuling tengah
- [ii] Titik potong
- [iii] Penyulingan ASTM
- [iv] Lengkuk peratus tengah
- [v] Gasolin larian terus

[5 markah]

[b] Data ASTM berikut diperolehi untuk gas minyak berat. Tukarkan data ASTM ke data TBP.

Isipadu	Suhu ASTM, °F
IBP	595
10	615
30	626
50	633
70	640
90	658
FBP	675

[8 markah]

[c] Bezakan antara yang berikut (ke titik):

- [i] Kerosin dan diesel
- [ii] Lengkuk titik didih sebenar (TBP) dan lengkuk keseimbangan pengewapan kilat (EFV)
- [iii] Mentah Ringan dan Mentah Berat
- [iv] Pam sekeliling dan Pam balikan refluks di dalam pemeringkat

[12 markah]

1. [a] Define the following Terms (in brief)

- [i] Middle Distillate
- [ii] Cut point
- [iii] ASTM distillation
- [iv] Mid percent curve
- [v] Straight run gasoline

[5 marks]

...3/-

- [b] The following ASTM data were obtained for heavy gas oil cut. Convert these ASTM data to TBP data.

Vol %	ASTM Temperature, °F
IBP	595
10	615
30	626
50	633
70	640
90	658
FBP	675

[8 marks]

- [c] Differentiate between the followings (To the point):

- [i] Kerosene and diesel
- [ii] True Boiling Point (TBP) curve and Equilibrium Flash Vaporisation (EFV) curve
- [iii] Light crude and Heavy crude
- [iv] Pump around and Pump back reflux in the fractionator.

[12 marks]

Bahagian B : Jawab mana-mana SATU soalan.

Section B : Answer any ONE question.

2. [a] Takrifkan sebutan-sebutan berikut:

- [i] titik awan
- [ii] nombor oktana motor
- [iii] titik curah
- [iv] tekanan wap Reid (RVP)
- [v] karbon 'conradson'

[10 markah]

- [b] Bincangkan 5 ujian-ujian utama dijalankan untuk diesel dan kepentingannya.

[10 markah]

- [c] Apakah simpanan dan penggunaan petroleum sedunia sekarang?

[5 markah]

...4/-

2. [a] *Define the following terms,*

[i] *cloud point*

[ii] *motor octane number*

[iii] *pour point*

[iv] *Reid Vapor Pressure (RVP)*

[v] *conradson carbon*

[10 marks]

[b] *Discuss 5 major tests conducted on diesel and their significance.*

[10 marks]

[c] *What is the present world petroleum reserves and consumption?*

[5 marks]

3. [a] *Perihalkan unit penyulingan atmosfera dan penyulingan vakum dalam proses penyulingan minyak mentah. Nyatakan pembolehubah proses bagi setiap unit.*

[5 markah]

[b] *Bincangkan proses-proses berikut dan kenapa ianya dijalankan:*

[i] *pengkokan terlengah*

[ii] *pemecahan bermangkin*

[iii] *pembentukan semula bermangkin*

[iv] *penghidropecahan bermangkin*

[v] *pemecahan vis*

[15 markah]

[c] *Senaraikan kebaikan-kebaikan mangkin zeolit dalam proses pemecahan bermangkin.*

[5 markah]

3. [a] *Describe atmospheric distillation and vacuum distillation units in crude oil distillation process. State the process variables for each unit.*

[5 marks]

...5/-

[b] *Discuss the following processes and why they are conducted.*

- [i] *delayed coking*
- [ii] *catalytic cracking*
- [iii] *catalytic reforming*
- [iv] *catalytic hydrocracking*
- [v] *visbreaking*

[15 marks]

[c] *List the advantages of zeolite catalyst in the catalytic cracking process.*

[5 marks]

Bahagian C - Jawab mana-mana DUA soalan.

Section C - Answer any TWO questions.

4. [a] *Lakarkan gambarajah aliran proses secara terperinci mengenai keadaan-keadaan proses dan maklumat-maklumat lain untuk penyingkiran H₂O dari gas asli melalui proses penjerapan.*

[10 markah]

[b] *Senaraikan 12 unit operasi dalam loji pemprosesan gas.*

[6 markah]

[c] *Satu campuran mengandungi 30 mol % metana, 10 mol % etana, 30 mol % propana, dan 30 mol % n-butana dibawa kepada keadaan bersuhu (-15°C) pada tekanan, P di mana ianya wujud sebagai campuran wap/cecair secara keseimbangan. Jika pecahan mol metana dalam fasa wap adalah 0.80, berapakah tekanan P (dalam bar)?*

[9 markah]

4. [a] *Draw the process flow diagram with details of the process conditions and other details for H₂O removal from natural gas by adsorption process.*

[10 marks]

[b] *List 12 unit operations in gas processing plants.*

[6 marks]

[c] *A mixture comprised of 30 mol % methane, 10 mol % ethane, 30 mol % propane, and 30 mol % n-butane is brought to a condition of (-15°C) at pressure P, where it exists as a vapor/liquid mixture in equilibrium. If the mole fraction of methane in the vapor phase is 0.80, what is the pressure P (in bar)?*

[9 marks]

...6/-

5. [a] Unsur sulfur dihasilkan daripada H_2S dalam Loji Claus. Lakarkan gambarajah proses dan nyatakan tindakbalas dan lain-lain keadaan-keadaan proses.

[8 markah]

- [b] Mengapakah gas asli dicecairkan dan apakah cecair Gas Asli (LNG)?

[4 markah]

- [c] Metana hendak dicecairkan dalam proses Linde yang mudah. Suapan dan kitar semula adalah dalam keadaan campuran, termampat sehingga 60 bar, dan diprapendingin ke 300 K. Wap tersebut kemudian melalui penukar haba untuk penyejukan tambahan sebelum dipendikit ke 1 bar. Pecahan bukan cecair meninggalkan pemisah pada suhu tepu dan melalui penukar haba wujud pada suhu 295 K.

[i] Berapakah pecahan gas yang dicecairkan dalam proses ini?

[ii] Berapakah suhu gas bertekanan tinggi yang memasuki injap pendikit?

[13 markah]

5. [a] *Elemental sulfur is produced from H_2S in the Claus Plant. Draw the process diagram, and outline the reactions and other process conditions.*

[8 marks]

- [b] *Why natural gas is liquefied and what is Liquefied Natural Gas (LNG)?*

[4 marks]

- [c] *Methane is to be liquefied in a simple Linde process. The feed and recycle are mixed, compressed to 60 bar, and pre-cooled to 300 K. The vapor then passes through a heat exchanger for additional cooling before being throttled to 1 bar. The unliquified fraction leaves the separator at the saturation temperature, and passes through the heat exchanger, then exist at 295 K.*

[i] *What fraction of the gas is liquefied in the process?*

[ii] *What is the temperature of the high-pressure gas entering the throttle valve?*

[13 marks]

6. [a] Bincangkan secara ringkas proses pemeringkatan cecair gas asli dan tujuannya.

[6 markah]

- [b] Sel bahan yang menggunakan kuasa gas asli sememangnya merupakan teknologi baru yang menjanjikan penjanaan elektrik yang lebih bersih dan cekap. Terangkan bagaimana sel bahan api bekerja dan apakah kebaikan-kebaikannya.

[7 markah]

...7/-

- [c] Penyejukan digunakan untuk membawa aliran supaya berada di bawah dari suhu ambient. Bincangkan kitar penyejukan propana pada gambarajah P-H (Tekanan-Entalpi).

[5 markah]

- [d] Jika 3.97 m^3 gas metana pada 15.6°C dan 1 bar adalah bersamaan dengan $3.785 \times 10^{-3} \text{ m}^3$ gasolin sebagai bahanapi untuk enjin kereta, berapakah isipadu tangki yang diperlukan untuk memenuhi metana pada 206.8 bar dan 15.6°C dengan jumlah yang bersamaan dengan 0.03785 m^3 gasolin.

[7 markah]

6. [a] *Briefly discuss the process of natural gas liquid fractionation and its purpose.*

[6 marks]

- [b] *Fuel cells powered by natural gas are an extremely exciting and promising new technology for the clean and efficient generation of electricity. Explain how a Fuel Cell works and its benefits.*

[7 marks]

- [c] *To bring a stream below the ambient temperature, refrigeration is used. Discuss the propane refrigeration cycle on P-H (Pressure-Enthalpy) diagram.*

[5 marks]

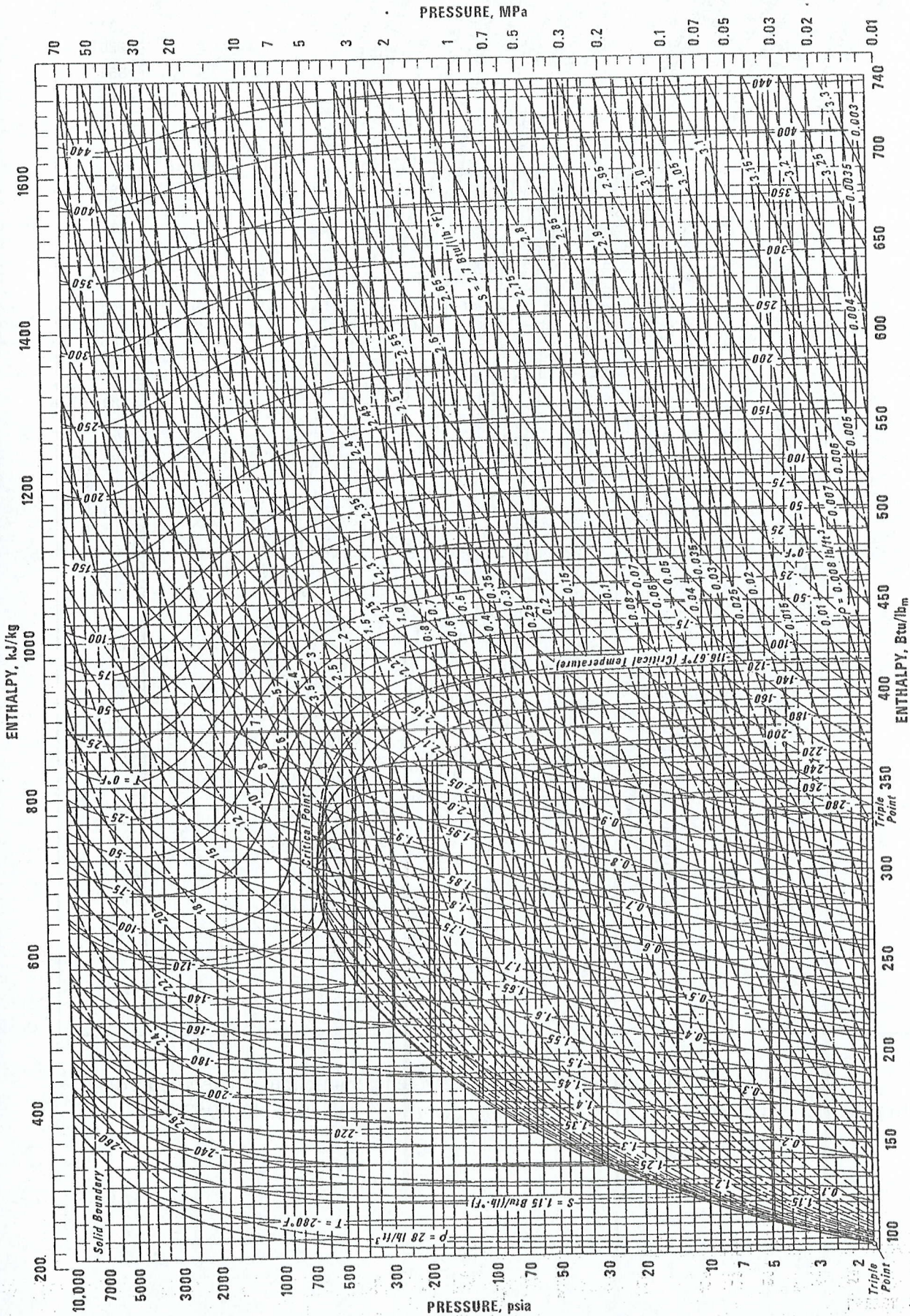
- [d] *If 3.97 m^3 of methane gas at 15.6°C and 1 bar is equivalent to $3.785 \times 10^{-3} \text{ m}^3$ of gasoline as fuel for an automobile engine, what would be the volume of the tank required to hold methane at 206.8 bar and 15.6°C in an amount equivalent to 0.03785 m^3 of gasoline?*

[7 marks]

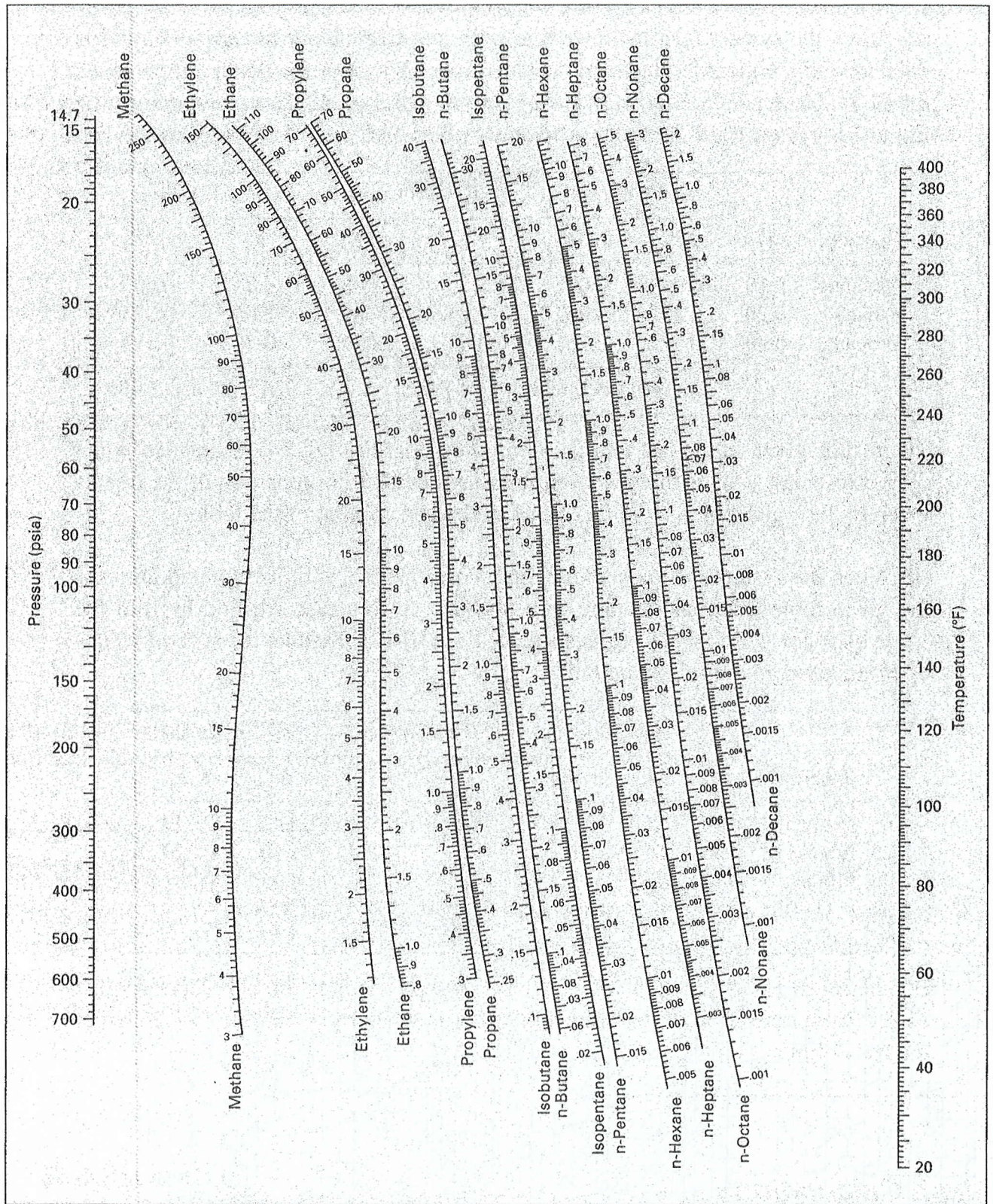
Appendix

PRESSURE-ENTHALPY DIAGRAM FOR METHANE

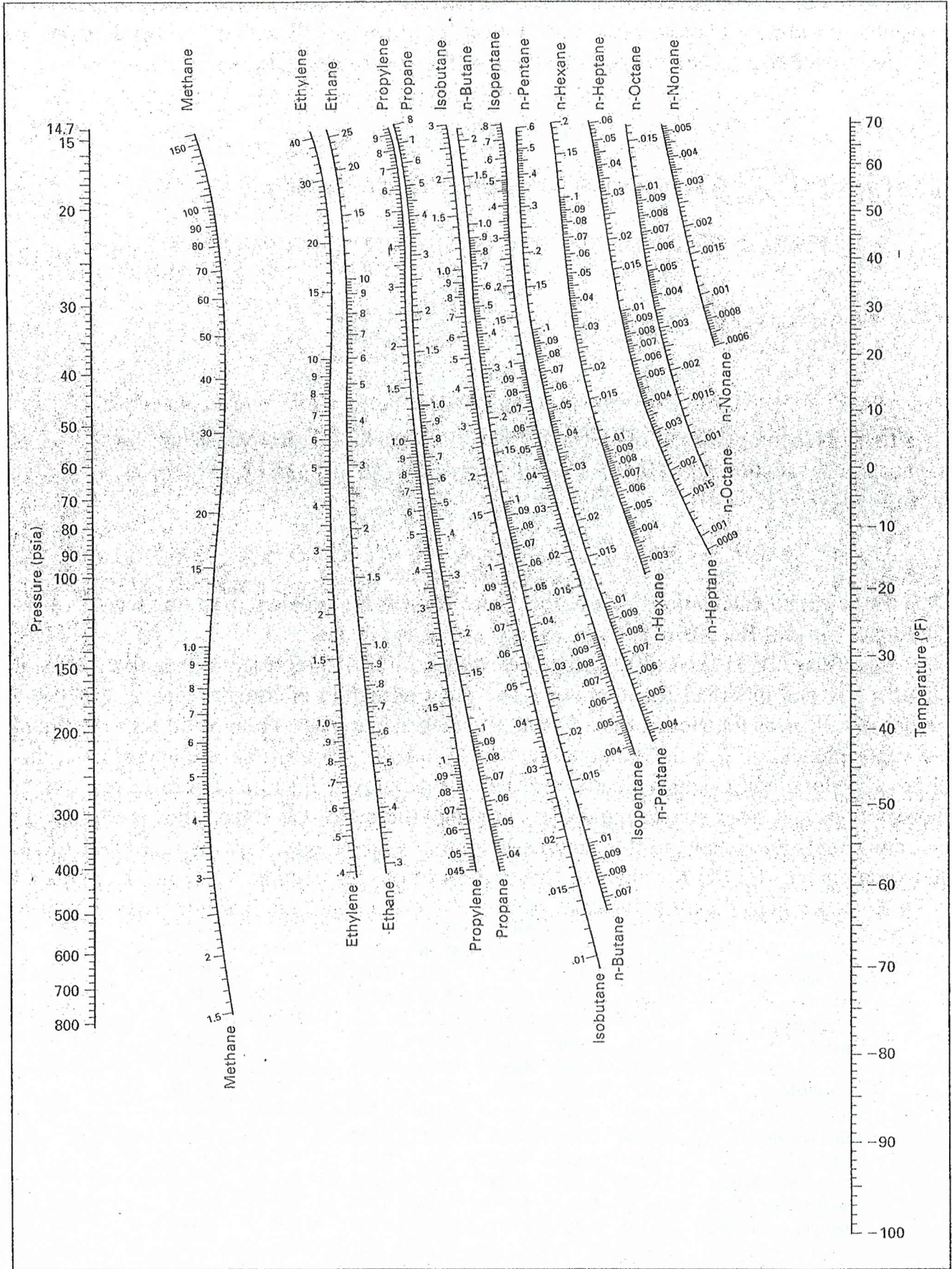
(Source: NIST, Thermophysics Division, Boulder, CO, USA, used with permission.)



...2/-



K-values for systems of light hydrocarbons. High-temperature range. (Reproduced by permission from C. L. DePriester, *Chem. Eng. Progr. Symp. Ser. No. 7*, vol. 49, p. 42, 1953.)



K-values for systems of light hydrocarbons. Low-temperature range. (Reproduced by permission from C. L. DePriester, *Chem. Eng. Progr. Symp. Ser. No. 7*, vol. 49, p. 41, 1953.) ...4/-

Properties of Pure Species

	Molar mass	ω	T_c/K	P_c/bar	Z_c	V_c $\text{cm}^3 \text{mol}^{-1}$	T_n/K
Methane	16.043	0.012	190.6	45.99	0.286	98.6	111.4
Ethane	30.070	0.100	305.3	48.72	0.279	145.5	184.6
Propane	44.097	0.152	369.8	42.48	0.276	200.0	231.1
<i>n</i> -Butane	58.123	0.200	425.1	37.96	0.274	255.	272.7
<i>n</i> -Pentane	72.150	0.252	469.7	33.70	0.270	313.	309.2
<i>n</i> -Hexane	86.177	0.301	507.6	30.25	0.266	371.	341.9
<i>n</i> -Heptane	100.204	0.350	540.2	27.40	0.261	428.	371.6
<i>n</i> -Octane	114.231	0.400	568.7	24.90	0.256	486.	398.8
<i>n</i> -Nonane	128.258	0.444	594.6	22.90	0.252	544.	424.0
<i>n</i> -Decane	142.285	0.492	617.7	21.10	0.247	600.	447.3
Isobutane	58.123	0.181	408.1	36.48	0.282	262.7	261.4
Isooctane	114.231	0.302	544.0	25.68	0.266	468.	372.4
Cyclopentane	70.134	0.196	511.8	45.02	0.273	258.	322.4
Cyclohexane	84.161	0.210	553.6	40.73	0.273	308.	353.9
Methylcyclopentane	84.161	0.230	532.8	37.85	0.272	319.	345.0
Methylcyclohexane	98.188	0.235	572.2	34.71	0.269	368.	374.1
Ethylene	28.054	0.087	282.3	50.40	0.281	131.	169.4
Propylene	42.081	0.140	365.6	46.65	0.289	188.4	225.5
1-Butene	56.108	0.191	420.0	40.43	0.277	239.3	266.9
<i>cis</i> -2-Butene	56.108	0.205	435.6	42.43	0.273	233.8	276.9
<i>trans</i> -2-Butene	56.108	0.218	428.6	41.00	0.275	237.7	274.0
1-Hexene	84.161	0.280	504.0	31.40	0.265	354.	336.3
Isobutylene	56.108	0.194	417.9	40.00	0.275	238.9	266.3
1,3-Butadiene	54.092	0.190	425.2	42.77	0.267	220.4	268.7
Cyclohexene	82.145	0.212	560.4	43.50	0.272	291.	356.1
Acetylene	26.038	0.187	308.3	61.39	0.271	113.	189.4
Benzene	78.114	0.210	562.2	48.98	0.271	259.	353.2
Toluene	92.141	0.262	591.8	41.06	0.264	316.	383.8
Ethylbenzene	106.167	0.303	617.2	36.06	0.263	374.	409.4
Cumene	120.194	0.326	631.1	32.09	0.261	427.	425.6
<i>o</i> -Xylene	106.167	0.310	630.3	37.34	0.263	369.	417.6
<i>m</i> -Xylene	106.167	0.326	617.1	35.36	0.259	376.	412.3
<i>p</i> -Xylene	106.167	0.322	616.2	35.11	0.260	379.	411.5
Styrene	104.152	0.297	636.0	38.40	0.256	352.	418.3
Naphthalene	128.174	0.302	748.4	40.51	0.269	413.	
Biphenyl	154.211	0.365	789.3	38.50	0.295	502.	528.2
Formaldehyde	30.026	0.282	408.0	65.90	0.223	115.	254.1
Acetaldehyde	44.053	0.291	466.0	55.50	0.221	154.	294.0
Methyl acetate	74.079	0.331	506.6	47.50	0.257	228.	330.1
Ethyl acetate	88.106	0.366	523.3	38.80	0.255	286.	350.2
Acetone	58.080	0.307	508.2	47.01	0.233	209.	329.4
Methyl ethyl ketone	72.107	0.323	535.5	41.50	0.249	267.	352.8
Diethyl ether	74.123	0.281	466.7	36.40	0.263	280.	307.6
Methyl <i>t</i> -butyl ether	88.150	0.266	497.1	34.30	0.273	329.	328.4

Values of Z^0

$P_r =$	1.0000	1.2000	1.5000	2.0000	3.0000	5.0000	7.0000	10.000
T_r								
0.30	0.2892	0.3479	0.4335	0.5775	0.8648	1.4366	2.0048	2.8507
0.35	0.2604	0.3123	0.3901	0.5195	0.7775	1.2902	1.7987	2.5539
0.40	0.2379	0.2853	0.3563	0.4744	0.7095	1.1758	1.6373	2.3211
0.45	0.2200	0.2638	0.3294	0.4384	0.6551	1.0841	1.5077	2.1338
0.50	0.2056	0.2465	0.3077	0.4092	0.6110	1.0094	1.4017	1.9801
0.55	0.1939	0.2323	0.2899	0.3853	0.5747	0.9475	1.3137	1.8520
0.60	0.1842	0.2207	0.2753	0.3657	0.5446	0.8959	1.2398	1.7440
0.65	0.1765	0.2113	0.2634	0.3495	0.5197	0.8526	1.1773	1.6519
0.70	0.1703	0.2038	0.2538	0.3364	0.4991	0.8161	1.1341	1.5729
0.75	0.1656	0.1981	0.2464	0.3260	0.4823	0.7854	1.0787	1.5047
0.80	0.1626	0.1942	0.2411	0.3182	0.4690	0.7598	1.0400	1.4456
0.85	0.1614	0.1924	0.2382	0.3132	0.4591	0.7388	1.0071	1.3943
0.90	0.1630	0.1935	0.2383	0.3114	0.4527	0.7220	0.9793	1.3496
0.93	0.1664	0.1963	0.2405	0.3122	0.4507	0.7138	0.9648	1.3257
0.95	0.1705	0.1998	0.2432	0.3138	0.4501	0.7092	0.9561	1.3108
0.97	0.1779	0.2055	0.2474	0.3164	0.4504	0.7052	0.9480	1.2968
0.98	0.1844	0.2097	0.2503	0.3182	0.4508	0.7035	0.9442	1.2901
0.99	0.1959	0.2154	0.2538	0.3204	0.4514	0.7018	0.9406	1.2835
1.00	0.2901	0.2237	0.2583	0.3229	0.4522	0.7004	0.9372	1.2772
1.01	0.4648	0.2370	0.2640	0.3260	0.4533	0.6991	0.9339	1.2710
1.02	0.5146	0.2629	0.2715	0.3297	0.4547	0.6980	0.9307	1.2650
1.05	0.6026	0.4437	0.3131	0.3452	0.4604	0.6956	0.9222	1.2481
1.10	0.6880	0.5984	0.4580	0.3953	0.4770	0.6950	0.9110	1.2232
1.15	0.7443	0.6803	0.5798	0.4760	0.5042	0.6987	0.9033	1.2021
1.20	0.7858	0.7363	0.6605	0.5605	0.5425	0.7069	0.8990	1.1844
1.30	0.8438	0.8111	0.7624	0.6908	0.6344	0.7358	0.8998	1.1580
1.40	0.8827	0.8595	0.8256	0.7753	0.7202	0.7761	0.9112	1.1419
1.50	0.9103	0.8933	0.8689	0.8328	0.7887	0.8200	0.9297	1.1339
1.60	0.9308	0.9180	0.9000	0.8738	0.8410	0.8617	0.9518	1.1320
1.70	0.9463	0.9367	0.9234	0.9043	0.8809	0.8984	0.9745	1.1343
1.80	0.9583	0.9511	0.9413	0.9275	0.9118	0.9297	0.9961	1.1391
1.90	0.9678	0.9624	0.9552	0.9456	0.9359	0.9557	1.0157	1.1452
2.00	0.9754	0.9715	0.9664	0.9599	0.9550	0.9772	1.0328	1.1516
2.20	0.9856	0.9847	0.9826	0.9806	0.9827	1.0094	1.0600	1.1635
2.40	0.9941	0.9936	0.9935	0.9945	1.0011	1.0313	1.0793	1.1728
2.60	0.9993	0.9998	1.0010	1.0040	1.0137	1.0463	1.0926	1.1792
2.80	1.0031	1.0042	1.0063	1.0106	1.0223	1.0565	1.1016	1.1830
3.00	1.0057	1.0074	1.0101	1.0153	1.0284	1.0635	1.1075	1.1848
3.50	1.0097	1.0120	1.0156	1.0221	1.0368	1.0723	1.1138	1.1834
4.00	1.0115	1.0140	1.0179	1.0249	1.0401	1.0747	1.1136	1.1773

Table Values of Z^1

$P_r =$	1.0000	1.2000	1.5000	2.0000	3.0000	5.0000	7.0000	10.000
T_r								
0.30	-0.0806	-0.0966	-0.1207	-0.1608	-0.2407	-0.3996	-0.5572	-0.7915
0.35	-0.0921	-0.1105	-0.1379	-0.1834	-0.2738	-0.4523	-0.6279	-0.8863
0.40	-0.0946	-0.1134	-0.1414	-0.1879	-0.2799	-0.4603	-0.6365	-0.8936
0.45	-0.0929	-0.1113	-0.1387	-0.1840	-0.2734	-0.4475	-0.6162	-0.8608
0.50	-0.0893	-0.1069	-0.1330	-0.1762	-0.2611	-0.4253	-0.5831	-0.8099
0.55	-0.0849	-0.1015	-0.1263	-0.1669	-0.2465	-0.3991	-0.5446	-0.7521
0.60	-0.0803	-0.0960	-0.1192	-0.1572	-0.2312	-0.3718	-0.5047	-0.6928
0.65	-0.0759	-0.0906	-0.1122	-0.1476	-0.2160	-0.3447	-0.4653	-0.6346
0.70	-0.0718	-0.0855	-0.1057	-0.1385	-0.2013	-0.3184	-0.4270	-0.5785
0.75	-0.0681	-0.0808	-0.0996	-0.1298	-0.1872	-0.2929	-0.3901	-0.5250
0.80	-0.0648	-0.0767	-0.0940	-0.1217	-0.1736	-0.2682	-0.3545	-0.4740
0.85	-0.0622	-0.0731	-0.0888	-0.1138	-0.1602	-0.2439	-0.3201	-0.4254
0.90	-0.0604	-0.0701	-0.0840	-0.1059	-0.1463	-0.2195	-0.2862	-0.3788
0.93	-0.0602	-0.0687	-0.0810	-0.1007	-0.1374	-0.2045	-0.2661	-0.3516
0.95	-0.0607	-0.0678	-0.0788	-0.0967	-0.1310	-0.1943	-0.2526	-0.3339
0.97	-0.0623	-0.0669	-0.0759	-0.0921	-0.1240	-0.1837	-0.2391	-0.3163
0.98	-0.0641	-0.0661	-0.0740	-0.0893	-0.1202	-0.1783	-0.2322	-0.3075
0.99	-0.0680	-0.0646	-0.0715	-0.0861	-0.1162	-0.1728	-0.2254	-0.2989
1.00	-0.0879	-0.0609	-0.0678	-0.0824	-0.1118	-0.1672	-0.2185	-0.2902
1.01	-0.0223	-0.0473	-0.0621	-0.0778	-0.1072	-0.1615	-0.2116	-0.2816
1.02	-0.0062	-0.0227	-0.0524	-0.0722	-0.1021	-0.1556	-0.2047	-0.2731
1.05	0.0220	0.1059	0.0451	-0.0432	-0.0838	-0.1370	-0.1835	-0.2476
1.10	0.0476	0.0897	0.1630	0.0698	-0.0373	-0.1021	-0.1469	-0.2056
1.15	0.0625	0.0943	0.1548	0.1667	0.0332	-0.0611	-0.1084	-0.1642
1.20	0.0719	0.0991	0.1477	0.1990	0.1095	-0.0141	-0.0678	-0.1231
1.30	0.0819	0.1048	0.1420	0.1991	0.2079	0.0875	0.0176	-0.0423
1.40	0.0857	0.1063	0.1383	0.1894	0.2397	0.1737	0.1008	0.0350
1.50	0.0854	0.1055	0.1345	0.1806	0.2433	0.2309	0.1717	0.1058
1.60	0.0855	0.1035	0.1303	0.1729	0.2381	0.2631	0.2255	0.1673
1.70	0.0838	0.1008	0.1259	0.1658	0.2305	0.2788	0.2628	0.2179
1.80	0.0816	0.0978	0.1216	0.1593	0.2224	0.2846	0.2871	0.2576
1.90	0.0792	0.0947	0.1173	0.1532	0.2144	0.2848	0.3017	0.2876
2.00	0.0767	0.0916	0.1133	0.1476	0.2069	0.2819	0.3097	0.3096
2.20	0.0719	0.0857	0.1057	0.1374	0.1932	0.2720	0.3135	0.3355
2.40	0.0675	0.0803	0.0989	0.1285	0.1812	0.2602	0.3089	0.3459
2.60	0.0634	0.0754	0.0929	0.1207	0.1706	0.2484	0.3009	0.3475
2.80	0.0598	0.0711	0.0876	0.1138	0.1613	0.2372	0.2915	0.3443
3.00	0.0535	0.0672	0.0828	0.1076	0.1529	0.2268	0.2817	0.3385
3.50	0.0497	0.0591	0.0728	0.0949	0.1356	0.2042	0.2584	0.3194
4.00	0.0443	0.0527	0.0651	0.0849	0.1219	0.1857	0.2378	0.2994

