

**King Mongkut's University of Technology Thonburi****Midterm Examination, Second Semester (2/2012)**

Course: CHE 242 Thermodynamics II

Chemical Engineering, 2<sup>nd</sup> yearDate: Friday 8<sup>th</sup> March 2013

Time: 9.00 – 12.00

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**Please follow the instructions.**

1. There are 4 questions, 1 Figure and 9 Tables in 19 pages, including the covering page and a graph.
2. A calculator and one A4 paper are allowed in the exam.

After you have finished with the examination, raise your hand for permission to leave the examination room,

Students are not allowed to take the examination paper out of the examination room.

If any disallowable material is found in your occupation in the examination room, you will be punished as serious as retirement.

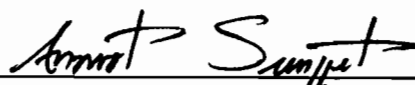
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This exam is evaluated by the committee of the Department of Chemical Engineering

  
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Head of Department

Name.....Student I.D. ....

- 1) Water vapor existing initially at 240°C and 550 kPa expands isothermally in a piston-cylinder assembly and without internal irreversibility to a final pressure of 350 kPa. Determine work done, in kJ/kg, if the expansion of the water vapor is explained by a truncated Virial equation of state with the following form:

$$Z = 1 + \frac{B}{V} + \frac{C}{V^2}$$

Where B and C are the constant parameters that could be evaluated from the available data from which the 4<sup>th</sup> decimal points for the V and Z calculation is required for more accuracy. (Hint:  $W = -\int P dV$ ) (30 Marks)

Name.....Student I.D. ....

- 2) The volume expansion coefficient (volume expansivity) of mercury at  $0^{\circ}\text{C}$  is  $18 \times 10^{-5} (\text{^{\circ}\text{C}})^{-1}$ . The coefficient of compressibility (isothermal compressibility) is  $5.32 \times 10^{-6} (\text{bar})^{-1}$ . If mercury is heated from  $0$  to  $1^{\circ}\text{C}$  undergoing constant-volume system, what pressure change would be developed? (10 Marks)

- 3) A closed rigid vessel with a good insulation having a volume of  $0.14 \text{ m}^3$  contains  $\text{O}_2$  initially at 100 atm and  $-87^\circ\text{C}$ .  $\text{O}_2$  is stirred by a paddle wheel in the vessel until the pressure rises to 300 atm, then the stirring stops and the gas reaches a final equilibrium state.

**Note :**  $T_c = 154.6 \text{ K}$ ,  $P_c = 50.43 \text{ bar}$ ,  $\omega = 0.022$  and  $C_p = 30 \text{ J/mol.K}$

$$\text{Antoine's Equation for } \text{O}_2: \log P (\text{mmHg}) = 6.69144 - \frac{319.013}{t(^{\circ}\text{C}) + 266.679}$$

- a) Estimate the final temperature of the  $\text{O}_2$  gas. (25 Marks)

Name.....Student I.D. ....

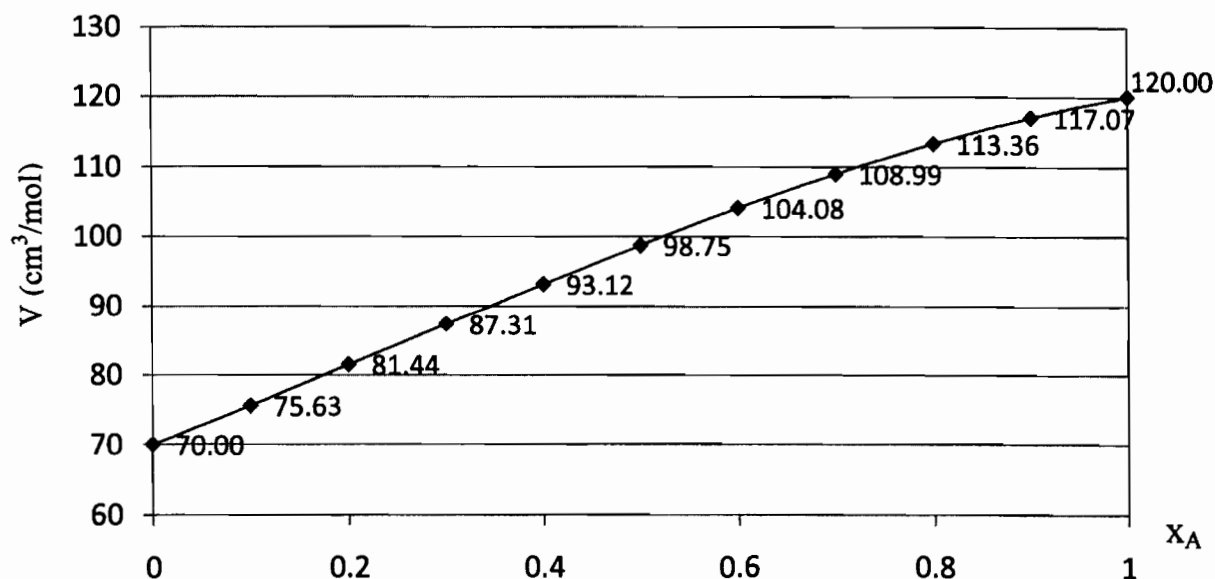
b) Determine work

(20 Marks)

(Hint:  $W + Q = n\Delta U$ )

Name.....Student I.D. ....

4. Molar Volume of the binary mixture between species A and B can be plotted versus mole fraction of species A as shown in the Figure below. Answer the following questions.



- a) If 7.5 mol of species A was mixed with 5 mol of species B, estimate the total volume of the mixture. (5 marks)
- b) From question a, estimate the total mixture volume occupied by species A. (5 marks)
- c) Estimate the volume occupied by 1 mol of species A, if the solution contained approximately pure species B. (5 marks)

Table 1 Values of  $Z^0$ 

$P_r =$	1.0000	1.2000	1.5000	2.0000	3.0000	5.0000	7.0000	10.0000
$T_r$								
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 2 Values of  $Z^1$ 

$P_r =$	1.0000	1.2000	1.5000	2.0000	3.0000	5.0000	7.0000	10.0000
$T_r$								
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

Table 3 Values of  $(H^R)^0 / RT_c$ 

$P_r =$	1.0000	1.2000	1.5000	2.0000	3.0000	5.0000	7.0000	10.0000
$T_r$								
0.30	-5.987	-5.975	-5.957	-5.927	-5.868	-5.748	-5.628	-5.446
0.35	-5.845	-5.833	-5.814	-5.721	-5.721	-5.595	-5.469	-5.278
0.40	-5.700	-5.687	-5.668	-5.572	-5.572	-5.442	-5.311	-5.113
0.45	-5.551	-5.538	-5.519	-5.421	-5.421	-5.288	-5.154	-4.950
0.50	-5.401	-5.388	-5.369	-5.279	-5.279	-5.135	-4.999	-4.791
0.55	-5.252	-5.239	-5.220	-5.187	-5.121	-4.986	-4.849	-4.638
0.60	-5.104	-5.091	-5.073	-5.041	-4.976	-4.842	-4.794	-4.492
0.65	-4.956	-4.949	-4.927	-4.896	-4.833	-4.702	-4.565	-4.353
0.70	-4.808	-4.797	-4.781	-4.752	-4.693	-4.566	-4.432	-4.221
0.75	-4.655	-4.646	-4.632	-4.607	-4.554	-4.434	-4.393	-4.095
0.80	-4.494	-4.488	-4.478	-4.459	-4.413	-4.303	-4.178	-3.974
0.85	-4.316	-4.316	-4.312	-4.302	-4.269	-4.173	-4.056	-3.857
0.90	-4.108	-4.118	-4.127	-4.132	-4.119	-4.043	-3.935	-3.744
0.93	-3.953	-3.976	-4.000	-4.020	-4.024	-3.963	-3.863	-3.678
0.95	-3.825	-3.865	-3.904	-3.940	-3.958	-3.910	-3.815	-3.634
0.97	-3.658	-3.732	-3.796	-3.853	-3.890	-3.856	-3.767	-3.591
0.98	-3.544	-3.652	-3.736	-3.806	-3.854	-3.829	-3.743	-3.569
0.99	-3.376	-3.558	-3.670	-3.758	-3.818	-3.801	-3.719	-3.548
1.00	-2.584	-3.441	-3.598	-3.706	-3.782	-3.774	-3.695	-3.526
1.01	-1.796	-3.283	-3.516	-3.652	-3.744	-3.746	-3.671	-3.505
1.02	-1.627	-3.039	-3.422	-3.595	-3.705	-3.718	-3.647	-3.484
1.05	-1.359	-2.034	-3.030	-3.398	-3.583	-3.632	-3.575	-3.420
1.10	-1.120	-1.487	-2.203	-2.965	-3.353	-3.484	-3.453	-3.315
1.15	-0.968	-1.239	-1.719	-2.479	-3.091	-3.329	-3.329	-3.211
1.20	-0.857	-1.076	-1.443	-2.079	-2.801	-3.166	-3.202	-3.107
1.30	-0.698	-0.860	-1.116	-1.560	-2.274	-2.825	-2.942	-2.899
1.40	-0.588	-0.716	-0.915	-1.253	-1.857	-2.486	-2.679	-2.692
1.50	-0.505	-0.611	-0.774	-1.046	-1.549	-2.175	-2.421	-2.486
1.60	-0.440	-0.531	-0.667	-0.894	-1.318	-1.904	-2.177	-2.285
1.70	-0.387	-0.446	-0.583	-0.777	-1.139	-1.672	-1.953	-2.091
1.80	-0.344	-0.413	-0.515	-0.683	-0.996	-1.476	-1.751	-1.908
1.90	-0.307	-0.368	-0.458	-0.606	-0.880	-1.309	-1.571	-1.736
2.00	-0.276	-0.330	-0.411	-0.541	-0.782	-1.167	-1.411	-1.577
2.20	-0.226	-0.269	-0.334	-0.437	-0.629	-0.937	-1.143	-1.295
2.40	-0.187	-0.222	-0.275	-0.359	-0.513	-0.761	-0.929	-1.058
2.60	-0.155	-0.185	-0.228	-0.297	-0.422	-0.621	-0.756	-0.858
2.80	-0.130	-0.154	-0.190	-0.246	-0.348	-0.508	-0.614	-0.689
3.00	-0.109	-0.129	-0.159	-0.205	-0.288	-0.415	-0.495	-0.545
3.50	-0.069	-0.081	-0.099	-0.127	-0.174	-0.239	-0.270	-0.264
4.00	-0.041	-0.048	-0.058	-0.072	-0.095	-0.116	-0.110	-0.061

Table 4 Values of  $(H^R)^1 / RT_c$ 

$P_r =$	1.0000	1.2000	1.5000	2.0000	3.0000	5.0000	7.0000	10.0000
$T_r$								
0.30	-11.062	-11.055	-11.044	-11.027	-10.992	-10.935	-10.872	-10.781
0.35	-10.640	-10.637	-10.632	-10.624	-10.609	-10.581	-10.554	-10.529
0.40	-10.121	-10.121	-10.121	-10.122	-10.123	-10.128	-10.135	-10.150
0.45	-9.525	-9.527	-9.531	-9.537	-9.549	-9.576	-9.611	-9.663
0.50	-8.888	-8.892	-8.899	-8.909	-8.932	-8.978	-9.030	-9.111
0.55	-8.238	-8.243	-8.252	-8.267	-8.298	-8.360	-8.425	-8.531
0.60	-7.596	-7.603	-7.614	-7.632	-7.669	-7.745	-7.824	-7.950
0.65	-6.980	-6.987	-6.997	-7.017	-7.059	-7.147	-7.239	-7.381
0.70	-6.388	-6.395	-6.407	-6.429	-6.475	-6.574	-6.677	-6.837
0.75	-5.824	-5.832	-5.845	-5.868	-5.918	-6.027	-6.142	-6.318
0.80	-5.285	-5.293	-5.306	-5.330	-5.385	-5.506	-5.632	-5.824
0.85	-4.763	-4.771	-4.784	-4.810	-4.872	-5.000	-5.149	-5.358
0.90	-4.249	-4.255	-4.268	-4.298	-4.371	-4.530	-4.688	-4.916
0.93	-3.934	-3.937	-3.951	-3.987	-4.073	-4.251	-4.422	-4.662
0.95	-3.712	-3.713	-3.730	-3.773	-3.873	-4.068	-4.248	-4.497
0.97	-3.470	-3.467	-3.492	-3.551	-3.670	-3.885	-4.077	-4.336
0.98	-3.332	-3.327	-3.363	-3.434	-3.568	-3.795	-3.992	-4.257
0.99	-3.164	-3.164	-3.223	-3.313	-3.464	-3.705	-3.909	-4.178
1.00	-2.471	-2.952	-3.065	-3.186	-3.358	-3.615	-3.825	-4.100
1.01	-1.375	-2.595	-2.880	-3.051	-3.251	-3.525	-3.742	-4.023
1.02	-1.180	-1.723	-2.650	-2.906	-3.142	-3.435	-3.661	-3.947
1.05	-0.877	-0.878	-1.496	-2.381	-2.800	-3.167	-3.418	-3.722
1.10	-0.617	-0.673	-0.617	-1.261	-2.167	-2.720	-3.023	-3.362
1.15	-0.459	-0.503	-0.487	-0.604	-1.497	-2.275	-2.641	-3.019
1.20	-0.349	-0.381	-0.381	-0.361	-0.934	-1.840	-2.273	-2.692
1.30	-0.203	-0.218	-0.218	-0.178	-0.300	-1.066	-1.592	-2.086
1.40	-0.111	-0.115	-0.128	-0.070	-0.044	-0.504	-1.012	-1.547
1.50	-0.049	-0.046	-0.032	0.008	0.078	-0.142	-0.556	-1.080
1.60	-0.005	0.004	0.023	0.065	0.151	0.082	-0.217	-0.689
1.70	0.027	0.040	0.063	0.109	0.202	0.223	0.028	-0.369
1.80	0.051	0.067	0.094	0.143	0.241	0.317	0.203	-0.112
1.90	0.070	0.088	0.117	0.169	0.271	0.381	0.330	0.092
2.00	0.085	0.105	0.136	0.190	0.295	0.428	0.424	0.255
2.20	0.106	0.128	0.163	0.221	0.331	0.493	0.551	0.489
2.40	0.120	0.144	0.181	0.242	0.356	0.535	0.631	0.645
2.60	0.130	0.156	0.194	0.257	0.376	0.567	0.687	0.754
2.80	0.137	0.164	0.204	0.269	0.391	0.591	0.729	0.836
3.00	0.142	0.170	0.211	0.278	0.403	0.611	0.763	0.899
3.50	0.152	0.181	0.224	0.294	0.425	0.650	0.827	1.015
4.00	0.158	0.188	0.233	0.306	0.442	0.680	0.874	1.097

Table 5 Values of  $(S^R)^0 / R$ 

$P_r =$	1.0000	1.2000	1.5000	2.0000	3.0000	5.0000	7.0000	10.0000
$T_r$								
0.30	-7.099	-6.935	-6.740	-6.497	-6.180	-5.847	-5.683	-5.578
0.35	-6.663	-6.497	-6.299	-6.052	-5.728	-5.376	-5.194	-5.060
0.40	-6.275	-6.109	-5.909	-5.660	-5.330	-4.967	-4.772	-4.619
0.45	-5.924	-5.757	-5.557	-5.306	-4.974	-4.603	-4.401	-4.234
0.50	-5.608	-5.441	-5.240	-4.989	-4.656	-4.282	-4.074	-3.899
0.55	-5.324	-5.157	-4.956	-4.706	-4.373	-3.998	-3.788	-3.607
0.60	-5.066	-4.900	-4.700	-4.451	-4.120	-3.747	-3.537	-3.353
0.65	-4.830	-4.665	-4.467	-4.220	-3.892	-3.523	-3.315	-3.131
0.70	-4.610	-4.446	-4.250	-4.007	-3.684	-3.322	-3.117	-2.935
0.75	-4.399	-4.238	-4.045	-3.807	-3.491	-3.138	-2.939	-2.761
0.80	-4.191	-4.034	-3.846	-3.615	-3.310	-2.970	-2.777	-2.605
0.85	-3.976	-3.825	-3.646	-3.425	-3.135	-2.812	-2.629	-2.463
0.90	-3.737	-3.599	-3.434	-3.231	-2.964	-2.663	-2.491	-2.334
0.93	-3.569	-3.444	-3.295	-3.108	-2.860	-2.577	-2.412	-2.262
0.95	-3.433	-3.326	-3.193	-3.023	-2.790	-2.520	-2.362	-2.215
0.97	-3.259	-3.188	-3.081	-2.932	-2.719	-2.463	-2.312	-2.170
0.98	-3.142	-3.106	-3.019	-2.884	-2.682	-2.436	-2.287	-2.148
0.99	-2.972	-3.010	-2.953	-2.835	-2.646	-2.408	-2.263	-2.126
1.00	-2.178	-2.893	-2.879	-2.784	-2.609	-2.380	-2.239	-2.105
1.01	-1.391	-2.736	-2.798	-2.730	-2.571	-2.352	-2.215	-2.083
1.02	-1.225	-2.495	-2.706	-2.673	-2.533	-2.325	-2.191	-2.062
1.05	-0.965	-1.523	-2.328	-2.483	-2.415	-2.242	-2.121	-2.001
1.10	-0.742	-1.012	-1.557	-2.081	-2.202	-2.104	-2.007	-1.903
1.15	-0.607	-0.790	-1.126	-1.649	-1.968	-1.966	-1.897	-1.810
1.20	-0.512	-0.651	-0.890	-1.308	-1.727	-1.827	-1.789	-1.722
1.30	-0.385	-0.478	-0.628	-0.891	-1.299	-1.554	-1.581	-1.556
1.40	-0.303	-0.375	-0.478	-0.663	-0.990	-1.303	-1.386	-1.402
1.50	-0.246	-0.299	-0.381	-0.520	-0.777	-1.088	-1.208	-1.260
1.60	-0.204	-0.247	-0.312	-0.421	-0.628	-0.913	-1.050	-1.130
1.70	-0.172	-0.208	-0.261	-0.350	-0.519	-0.773	-0.915	-1.013
1.80	-0.147	-0.177	-0.222	-0.296	-0.438	-0.661	-0.799	-0.908
1.90	-0.127	-0.153	-0.191	-0.255	-0.375	-0.570	-0.702	-0.815
2.00	-0.111	-0.134	-0.167	-0.221	-0.325	-0.497	-0.620	-0.733
2.20	-0.087	-0.105	-0.130	-0.172	-0.251	-0.388	-0.492	-0.599
2.40	-0.070	-0.084	-0.104	-0.138	-0.201	-0.311	-0.399	-0.496
2.60	-0.058	-0.069	-0.086	-0.113	-0.164	-0.255	-0.329	-0.416
2.80	-0.048	-0.058	-0.072	-0.094	-0.137	-0.213	-0.277	-0.353
3.00	-0.041	-0.049	-0.061	-0.080	-0.116	-0.181	-0.236	-0.303
3.50	-0.029	-0.034	-0.042	-0.056	-0.081	-0.126	-0.166	-0.216
4.00	-0.021	-0.025	-0.031	-0.041	-0.059	-0.093	-0.123	-0.162

Table 6 Values of  $(S^R)^1/R$ 

$P_r =$	1.0000	1.2000	1.5000	2.0000	3.0000	5.0000	7.0000	10.0000
$T_r$								
0.30	-16.586	-16.547	-16.488	-16.390	-16.195	-15.837	-15.468	-14.925
0.35	-15.278	-15.251	-15.211	-15.144	-15.011	-14.751	-14.496	-14.153
0.40	-13.896	-13.877	-13.849	-13.803	-13.714	-13.541	-13.376	-13.144
0.45	-12.496	-12.482	-12.462	-12.430	-12.367	-12.248	-12.145	-11.999
0.50	-11.153	-11.143	-11.129	-11.107	-11.063	-10.985	-10.920	-10.836
0.55	-9.914	-9.907	-9.897	-9.882	-9.853	-9.806	-9.769	-9.732
0.60	-8.799	-8.794	-8.787	-8.777	-8.760	-8.736	-8.723	-8.720
0.65	-7.810	-7.807	-7.801	-7.794	-7.784	-7.779	-7.785	-7.811
0.70	-6.933	-6.930	-6.926	-6.922	-6.919	-6.929	-6.952	-7.002
0.75	-6.155	-6.152	-6.149	-6.147	-6.149	-6.174	-6.213	-6.285
0.80	-5.458	-5.455	-5.453	-5.452	-5.461	-5.501	-5.555	-5.648
0.85	-4.826	-4.822	-4.820	-4.822	-4.839	-4.898	-4.969	-5.082
0.90	-4.238	-4.232	-4.230	-4.236	-4.267	-4.351	-4.442	-4.578
0.93	-3.894	-3.885	-3.884	-3.896	-3.941	-4.046	-4.151	-4.300
0.95	-3.658	-3.647	-3.648	-3.669	-3.728	-3.851	-3.966	-4.125
0.97	-3.406	-3.391	-3.401	-3.437	-3.517	-3.661	-3.788	-3.957
0.98	-3.264	-3.247	-3.268	-3.318	-3.412	-3.569	-3.701	-3.875
0.99	-3.093	-3.082	-3.126	-3.195	-3.306	-3.477	-3.616	-3.796
1.00	-2.399	-2.868	-2.967	-3.067	-3.200	-3.387	-3.532	-3.717
1.01	-1.306	-2.513	-2.784	-2.933	-3.094	-3.297	-3.450	-3.640
1.02	-1.113	-1.655	-2.557	-2.790	-2.986	-3.209	-3.369	-3.565
1.05	-0.820	-0.831	-1.443	-2.283	-2.655	-2.949	-3.134	-3.348
1.10	-0.577	-0.640	-0.618	-1.241	-2.067	-2.534	-2.767	-3.013
1.15	-0.437	-0.489	-0.502	-0.654	-1.471	-2.138	-2.428	-2.708
1.20	-0.343	-0.385	-0.412	-0.447	-0.991	-1.767	-2.115	-2.430
1.30	-0.226	-0.254	-0.282	-0.300	-0.481	-1.147	-1.569	-1.944
1.40	-0.158	-0.178	-0.200	-0.220	-0.290	-0.730	-1.138	-1.544
1.50	-0.115	-0.130	-0.147	-0.166	-0.206	-0.479	-0.823	-1.222
1.60	-0.086	-0.098	-0.112	-0.129	-0.159	-0.334	-0.604	-0.969
1.70	-0.067	-0.076	-0.087	-0.102	-0.127	-0.248	-0.456	-0.775
1.80	-0.053	-0.060	-0.070	-0.083	-0.105	-0.195	-0.355	-0.628
1.90	-0.043	-0.049	-0.057	-0.069	-0.089	-0.160	-0.286	-0.518
2.00	-0.035	-0.040	-0.048	-0.058	-0.077	-0.136	-0.238	-0.434
2.20	-0.025	-0.029	-0.035	-0.043	-0.060	-0.105	-0.178	-0.322
2.40	-0.019	-0.022	-0.027	-0.034	-0.048	-0.086	-0.143	-0.254
2.60	-0.015	-0.018	-0.021	-0.028	-0.041	-0.074	-0.120	-0.210
2.80	-0.012	-0.014	-0.018	-0.023	-0.035	-0.065	-0.104	-0.180
3.00	-0.010	-0.012	-0.015	-0.020	-0.031	-0.058	-0.093	-0.158
3.50	-0.007	-0.009	-0.011	-0.015	-0.024	-0.046	-0.073	-0.122
4.00	-0.006	-0.007	-0.009	-0.012	-0.020	-0.038	-0.060	-0.100

**Table 7 Parameter Assignments for Equations of State**

For use with Eqs. (3.49) through (3.56)

Eq. of State	$\alpha(T_r)$	$\sigma$	$\epsilon$	$\Omega$	$\Psi$	$Z_c$
vdW (1873)	1	0	0	1/8	27/64	3/8
RK (1949)	$T_r^{-1/2}$	1	0	0.08664	0.42748	1/3
SRK (1972)	$\alpha_{\text{SRK}}(T_r; \omega)^\dagger$	1	0	0.08664	0.42748	1/3
PR (1976)	$\alpha_{\text{PR}}(T_r; \omega)^\ddagger$	$1 + \sqrt{2}$	$1 - \sqrt{2}$	0.07780	0.45724	0.30740

$$^\dagger \alpha_{\text{SRK}}(T_r; \omega) = \left[ 1 + (0.480 + 1.574\omega - 0.176\omega^2) \left( 1 - T_r^{1/2} \right) \right]^2$$

$$^\ddagger \alpha_{\text{PR}}(T_r; \omega) = \left[ 1 + (0.37464 + 1.54226\omega - 0.26992\omega^2) \left( 1 - T_r^{1/2} \right) \right]^2$$

$$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1} = 83.14 \text{ cm}^3 \text{ bar mol}^{-1} \text{ K}^{-1} = 8,314 \text{ cm}^3 \text{ kPa mol}^{-1} \text{ K}^{-1}$$

**Conversion factor table for Pressure**

mm Hg	in. Hg	bar	atm	kPa	psia
1	$3.937 \times 10^{-2}$	$1.333 \times 10^{-3}$	$1.316 \times 10^{-3}$	0.1333	$1.934 \times 10^{-2}$
25.4	1	$3.386 \times 10^1$	$3.342 \times 10^{-2}$	3.386	0.4912
750.06	29.53	1	0.9869	100.0	$1.415 \times 10^{-3}$
760.0	29.92	1.013	1	101.3	14.696
75.02	0.2954	$1.000 \times 10^{-2}$	$9.872 \times 10^{-3}$	1	0.1451
51.71	2.036	$6.893 \times 10^{-2}$	$6.805 \times 10^{-2}$	6.893	1

$$1 \text{ mmHg} = 0.1333 \text{ kPa} = 1.333 \times 10^{-3} \text{ bar} = 1.316 \times 10^{-3} \text{ atm} = 1.934 \times 10^{-2} \text{ psia}$$

Table 1. Saturated Steam, SI Units (Continued)

$t$ °C	$T$ K	$P$ kPa	SPECIFIC VOLUME $V$			INTERNAL ENERGY $U$			ENTHALPY $H$			ENTROPY $S$		
			sat. liq.	evap.	sat. vap.	sat. liq.	evap.	sat. vap.	sat. liq.	evap.	sat. vap.	sat. liq.	evap.	sat. vap.
220	493.15	2319.8	1.190	84.85	86.04	940.9	1659.4	2600.3	943.7	1856.2	2799.9	2.5178	3.7639	6.2817
222	495.15	2409.9	1.194	81.67	82.86	950.1	1650.7	2600.8	952.9	1847.5	2800.5	2.5363	3.7311	6.2674
224	497.15	2502.7	1.197	78.62	79.82	959.2	1642.0	2601.2	962.2	1838.7	2800.9	2.5548	3.6984	6.2532
226	499.15	2598.2	1.201	75.71	76.91	968.4	1633.1	2601.5	971.5	1829.8	2801.4	2.5733	3.6657	6.2390
228	501.15	2696.5	1.205	72.92	74.12	977.6	1624.2	2601.8	980.9	1820.8	2801.7	2.5917	3.6331	6.2249
230	503.15	2797.6	1.209	70.24	71.45	986.9	1615.2	2602.1	990.3	1811.7	2802.0	2.6102	3.6006	6.2107
232	505.15	2901.6	1.213	67.68	68.89	996.2	1606.1	2602.3	999.7	1802.5	2802.2	2.6286	3.5681	6.1967
234	507.15	3008.6	1.217	65.22	66.43	1005.4	1597.0	2602.4	1009.1	1793.2	2802.3	2.6470	3.5356	6.1826
236	509.15	3118.6	1.221	62.86	64.08	1014.8	1587.7	2602.5	1018.6	1783.8	2802.3	2.6653	3.5033	6.1686
238	511.15	3231.7	1.225	60.60	61.82	1024.1	1578.4	2602.5	1028.1	1774.2	2802.3	2.6837	3.4709	6.1546
240	513.15	3347.8	1.229	58.43	59.65	1033.5	1569.0	2602.5	1037.6	1764.6	2802.2	2.7020	3.4386	6.1406
242	515.15	3467.2	1.233	56.34	57.57	1042.9	1559.5	2602.4	1047.2	1754.9	2802.0	2.7203	3.4063	6.1266
244	517.15	3589.8	1.238	54.34	55.58	1052.3	1549.9	2602.2	1056.8	1745.0	2801.8	2.7386	3.3740	6.1127
246	519.15	3715.7	1.242	52.41	53.66	1061.8	1540.2	2602.0	1066.4	1735.0	2801.4	2.7569	3.3418	6.0987
248	521.15	3844.9	1.247	50.56	51.81	1071.3	1530.5	2601.8	1076.1	1724.9	2801.0	2.7752	3.3096	6.0848
250	523.15	3977.6	1.251	48.79	50.04	1080.8	1520.6	2601.4	1085.8	1714.7	2800.4	2.7935	3.2773	6.0708
252	525.15	4113.7	1.256	47.08	48.33	1090.4	1510.6	2601.0	1095.5	1704.3	2799.8	2.8118	3.2451	6.0569
254	527.15	4253.4	1.261	45.43	46.69	1100.0	1500.5	2600.5	1105.3	1693.8	2799.1	2.8300	3.2129	6.0429
256	529.15	4396.7	1.266	43.85	45.11	1109.8	1490.4	2600.0	1115.2	1683.2	2798.3	2.8483	3.1807	6.0290
258	531.15	4543.7	1.271	42.33	43.60	1119.3	1480.1	2599.3	1125.0	1672.4	2797.4	2.8666	3.1484	6.0150
260	533.15	4694.3	1.276	40.86	42.13	1129.0	1469.7	2598.6	1134.9	1661.5	2796.4	2.8848	3.1161	6.0010
262	535.15	4848.8	1.281	39.44	40.73	1138.7	1459.2	2597.8	1144.9	1650.4	2795.3	2.9031	3.0838	5.9869
264	537.15	5007.1	1.286	38.08	39.37	1148.5	1448.5	2597.0	1154.9	1639.2	2794.1	2.9214	3.0515	5.9729
266	539.15	5169.3	1.291	36.77	38.06	1158.3	1437.8	2596.1	1165.0	1627.8	2792.8	2.9397	3.0191	5.9588
268	541.15	5335.5	1.297	35.51	36.80	1168.2	1426.9	2595.0	1175.1	1616.3	2791.4	2.9580	2.9866	5.9446
270	543.15	5505.8	1.303	34.29	35.59	1178.1	1415.9	2593.9	1185.2	1604.6	2789.9	2.9763	2.9541	5.9304
272	545.15	5680.2	1.308	33.11	34.42	1188.0	1404.7	2592.7	1195.4	1592.8	2788.2	2.9947	2.9215	5.9162
274	547.15	5858.7	1.314	31.97	33.29	1198.0	1393.4	2591.4	1205.7	1580.8	2786.5	3.0131	2.8889	5.9019
276	549.15	6041.5	1.320	30.88	32.20	1208.0	1382.0	2590.1	1216.0	1568.5	2784.6	3.0314	2.8561	5.8876
278	551.15	6228.7	1.326	29.82	31.14	1218.1	1370.4	2588.6	1226.4	1556.2	2782.6	3.0499	2.8233	5.8731
280	553.15	6420.2	1.332	28.79	30.13	1228.3	1358.7	2587.0	1236.8	1543.6	2780.4	3.0683	2.7903	5.8586
282	555.15	6616.1	1.339	27.81	29.14	1238.5	1346.8	2585.3	1247.3	1530.8	2778.1	3.0868	2.7573	5.8440
284	557.15	6816.6	1.345	26.85	28.20	1248.7	1334.8	2583.5	1257.9	1517.8	2775.7	3.1053	2.7241	5.8294
286	559.15	7021.8	1.352	25.93	27.28	1259.0	1322.6	2581.6	1268.5	1504.6	2773.2	3.1238	2.6908	5.8146
288	561.15	7231.5	1.359	25.03	26.39	1269.4	1310.2	2579.6	1279.2	1491.2	2770.5	3.1424	2.6573	5.7997
290	563.15	7446.1	1.366	24.17	25.54	1279.8	1297.7	2577.5	1290.0	1477.6	2767.6	3.1611	2.6237	5.7848
292	565.15	7665.4	1.373	23.33	24.71	1290.3	1284.9	2575.3	1300.9	1463.8	2764.6	3.1798	2.5899	5.7697
294	567.15	7889.7	1.381	22.52	23.90	1300.9	1272.0	2572.9	1311.8	1449.7	2761.5	3.1985	2.5560	5.7545
296	569.15	8118.9	1.388	21.74	23.13	1311.5	1258.9	2570.4	1322.8	1435.4	2758.2	3.2173	2.5218	5.7392
298	571.15	8353.2	1.396	20.98	22.38	1322.2	1245.6	2567.8	1333.9	1420.8	2754.7	3.2362	2.4875	5.7237

$v$  = specific volume,  $\text{cm}^3/\text{g}$

$u$  = specific internal energy,  $\text{kJ}/\text{kg}$

$h$  = specific enthalpy,  $\text{kJ}/\text{kg}$

$s$  = specific entropy,  $\text{kJ}/\text{kg}\cdot\text{K}$

300	573.15	8592.7	1.404	20.24	21.65	1333.0	1232.0	2565.0	1345.1	1406.0	2751.0	3.2552	2.4529	5.7081
302	575.15	8837.4	1.412	19.53	20.94	1343.8	1218.3	2562.1	1356.3	1390.9	2747.2	3.2742	2.4182	5.6924
304	577.15	9087.3	1.421	18.84	20.26	1354.8	1204.3	2559.1	1367.7	1375.5	2743.2	3.2933	2.3832	5.6765
306	579.15	9342.7	1.430	18.17	19.60	1365.8	1190.1	2555.9	1379.1	1359.8	2739.0	3.3125	2.3479	5.6604
308	581.15	9603.6	1.439	17.52	18.96	1376.9	1175.6	2552.5	1390.7	1343.9	2734.6	3.3318	2.3124	5.6442
310	583.15	9870.0	1.448	16.89	18.33	1388.1	1161.0	2549.1	1402.4	1327.6	2730.0	3.3512	2.2766	5.6278
312	585.15	10142.1	1.458	16.27	17.73	1399.4	1146.0	2545.4	1414.2	1311.0	2725.2	3.3707	2.2404	5.6111
314	587.15	10420.0	1.468	15.68	17.14	1410.8	1130.8	2541.6	1426.1	1294.1	2720.2	3.3903	2.2040	5.5943
316	589.15	10703.1	1.478	15.09	16.57	1422.3	1115.2	2537.5	1438.1	1276.8	2714.9	3.4101	2.1672	5.5772
318	591.15	10993.4	1.488	14.53	16.02	1433.9	1099.4	2533.3	1450.3	1259.1	2709.4	3.4300	2.1300	5.5599
320	593.15	11289.1	1.500	13.98	15.48	1445.7	1083.2	2528.9	1462.6	1241.1	2703.7	3.4500	2.0923	5.5423
322	595.15	11591.0	1.511	13.44	14.96	1457.5	1066.7	2524.3	1475.1	1222.6	2697.6	3.4702	2.0542	5.5244
324	597.15	11899.2	1.523	12.92	14.45	1469.5	1049.9	2519.4	1487.7	1203.6	2691.3	3.4906	2.0156	5.5062
326	599.15	12213.7	1.535	12.41	13.95	1481.7	1032.6	2514.3	1500.4	1184.2	2684.6	3.5111	1.9764	5.4876
328	601.15	12534.8	1.548	11.91	13.46	1494.0	1014.8	2508.8	1513.4	1164.2	2677.6	3.5319	1.9367	5.4685
330	603.15	12862.5	1.561	11.43	12.99	1506.4	996.7	2503.1	1526.5	1143.6	2670.2	3.5528	1.8962	5.4490
332	605.15	13197.0	1.575	10.95	12.53	1519.1	978.0	2497.0	1539.9	1122.5	2662.3	3.5740	1.8550	5.4290
334	607.15	13538.3	1.590	10.49	12.08	1531.9	958.7	2490.6	1553.4	1100.7	2654.1	3.5955	1.8129	5.4084
336	609.15	13886.7	1.606	10.03	11.63	1544.9	938.9	2483.7	1567.2	1078.1	2645.3	3.6172	1.7700	5.3872
338	611.15	14242.3	1.622	9.58	11.20	1558.1	918.4	2476.4	1581.2	1054.8	2636.0	3.6392	1.7261	5.3653
340	613.15	14605.2	1.639	9.14	10.78	1571.5	897.2	2468.7	1595.5	1030.7	2626.2	3.6616	1.6811	5.3427
342	615.15	14975.5	1.657	8.71	10.37	1585.2	875.2	2460.5	1610.0	1005.7	2615.7	3.6844	1.6350	5.3194
344	617.15	15353.5	1.676	8.286	9.962	1599.2	852.5	2451.7	1624.9	979.7	2604.7	3.7075	1.5877	5.2952
346	619.15	15739.3	1.696	7.870	9.566	1613.5	828.9	2442.4	1640.2	952.8	2593.0	3.7311	1.5391	5.2702
348	621.15	16133.1	1.718	7.461	9.178	1628.1	804.5	2432.6	1655.8	924.8	2580.7	3.7553	1.4891	5.2444
350	623.15	16535.1	1.741	7.058	8.799	1643.0	779.2	2422.2	1671.8	895.9	2567.7	3.7801	1.4375	5.2177
352	625.15	16945.5	1.766	6.654	8.420	1659.4	751.5	2410.8	1689.3	864.2	2553.5	3.8071	1.3822	5.1893
354	627.15	17364.4	1.794	6.252	8.045	1676.3	722.4	2398.7	1707.5	830.9	2538.4	3.8349	1.3247	5.1596
356	629.15	17792.2	1.824	5.850	7.674	1693.4	692.2	2385.6	1725.9	796.2	2522.1	3.8629	1.2654	5.1283
358	631.15	18229.0	1.858	5.448	7.306	1710.8	660.5	2371.4	1744.7	759.9	2504.6	3.8915	1.2037	5.0953
360	633.15	18675.1	1.896	5.044	6.940	1728.8	627.1	2355.8	1764.2	721.3	2485.4	3.9210	1.1390	5.0600
361	634.15	18901.7	1.917	4.840	6.757	1738.0	609.5	2347.5	1774.2	701.0	2475.2	3.9362	1.1052	5.0414
362	635.15	19130.7	1.939	4.634	6.573	1747.5	591.2	2338.7	1784.6	679.8	2464.4	3.9518	1.0702	5.0220
363	636.15	19362.1	1.963	4.425	6.388	1757.3	572.1	2329.3	1795.3	657.8	2453.0	3.9679	1.0338	5.0017
364	637.15	19596.1	1.988	4.213	6.201	1767.4	552.0	2319.4	1806.4	634.6	2440.9	3.9846	0.9958	4.9804
365	638.15	19832.6	2.016	3.996	6.012	1778.0	530.8	2308.8	1818.0	610.0	2428.0	4.0021	0.9558	4.9579
366	639.15	20071.6	2.046	3.772	5.819	1789.1	508.2	2297.3	1830.2	583.9	2414.1	4.0205	0.9134	4.9339
367	640.15	20313.1	2.076	3.548	5.624	1800.0	486.9	2284.8	1842.2	555.7	2399.0	4.0401	0.8680	4.9081

Table F.2. Superheated Steam, SI Units (Continued)

		TEMPERATURE: $t$ °C (TEMPERATURE: $T$ kelvins)									
$P/kPa$ $t_{sat}/T_{sat}$ (°C/K)		sat. liq.	sat. vap.	150 (423.15)	175 (448.15)	200 (473.15)	220 (493.15)	240 (513.15)	260 (533.15)	280 (553.15)	300 (573.15)
325 (136.29/409.44)	V	1.076	561.75	583.58	622.41	660.33	690.22	719.81	749.18	778.39	807.47
	U	572.847	2545.7	2568.7	2609.6	2649.6	2681.2	2712.7	2744.0	2775.3	2806.6
	H	573.197	2728.3	2758.4	2811.9	2864.2	2905.6	2946.6	2987.5	3028.2	3069.0
	S	1.7004	6.9640	7.0363	7.1592	7.2729	7.3585	7.4400	7.5181	7.5933	7.6657
350 (138.87/412.02)	V	1.079	524.00	540.58	576.90	612.31	640.18	667.75	695.09	722.27	749.33
	U	583.892	2548.2	2567.1	2608.3	2648.6	2680.4	2712.0	2743.4	2774.8	2806.2
	H	584.270	2731.6	2756.3	2810.3	2863.0	2904.5	2945.7	2986.7	3027.6	3068.4
	S	1.7273	6.9392	6.9982	7.1222	7.2366	7.3226	7.4045	7.4828	7.5581	7.6307
375 (141.31/414.46)	V	1.081	491.13	503.29	537.46	570.69	596.81	622.62	648.22	673.64	698.94
	U	594.332	2550.6	2565.4	2607.1	2647.7	2679.6	2711.3	2742.8	2774.3	2805.7
	H	594.737	2734.7	2754.1	2808.6	2861.7	2903.4	2944.8	2985.9	3026.9	3067.8
	S	1.7526	6.9160	6.9624	7.0875	7.2027	7.2891	7.3713	7.4499	7.5254	7.5981
400 (143.62/416.77)	V	1.084	462.22	470.66	502.93	534.26	558.85	583.14	607.20	631.09	654.85
	U	604.237	2552.7	2563.7	2605.8	2646.7	2678.8	2710.6	2742.2	2773.7	2805.3
	H	604.670	2737.6	2752.0	2807.0	2860.4	2902.3	2943.9	2985.1	3026.2	3067.2
	S	1.7764	6.8943	6.9285	7.0548	7.1708	7.2576	7.3402	7.4190	7.4947	7.5675
425 (145.82/418.97)	V	1.086	436.61	441.85	472.47	502.12	525.36	548.30	571.01	593.54	615.95
	U	613.667	2554.8	2562.0	2604.5	2645.7	2678.0	2709.9	2741.6	2773.2	2804.8
	H	614.128	2740.3	2749.8	2805.3	2859.1	2901.2	2942.9	2984.3	3025.5	3066.6
	S	1.7990	6.8739	6.8965	7.0239	7.1407	7.2280	7.3108	7.3899	7.4657	7.5388
450 (147.92/421.07)	V	1.088	413.75	416.24	445.38	473.55	495.59	517.33	538.83	560.17	581.37
	U	622.672	2556.7	2560.3	2603.2	2644.7	2677.1	2709.2	2741.0	2772.7	2804.4
	H	623.162	2742.9	2747.7	2803.7	2857.8	2900.2	2942.0	2983.5	3024.8	3066.0
	S	1.8204	6.8547	6.8660	6.9946	7.1121	7.1999	7.2831	7.3624	7.4384	7.5116
475 (149.92/423.07)	V	1.091	393.22	393.31	421.14	447.97	468.95	489.62	510.05	530.30	550.43
	U	631.294	2558.5	2558.6	2601.9	2643.7	2676.3	2708.5	2740.4	2772.2	2803.9
	H	631.812	2745.3	2745.5	2802.0	2856.5	2899.1	2941.1	2982.7	3024.1	3065.4
	S	1.8408	6.8365	6.8369	6.9667	7.0850	7.1732	7.2567	7.3363	7.4125	7.4858
500 (151.84/424.99)	V	1.093	374.68	.....	399.31	424.96	444.97	464.67	484.14	503.43	522.58
	U	639.569	2560.2	.....	2600.6	2642.7	2675.5	2707.8	2739.8	2771.7	2803.5
	H	640.116	2747.5	.....	2800.3	2855.1	2898.0	2940.1	2981.9	3023.4	3064.8
	S	1.8604	6.8192	.....	6.9400	7.0592	7.1478	7.2317	7.3115	7.3879	7.4614

Units of  $v, u, h, s$  can be found from Table 8

525 (153.69/426.84)	V	1.095	357.84	.....	379.56	404.13	423.28	442.11	460.70	479.11	497.38
	U	647.528	2561.8	.....	2599.3	2641.6	2674.6	2707.1	2739.2	2771.2	2803.0
	H	648.103	2749.7	.....	2798.6	2853.8	2896.8	2939.2	2981.1	3022.7	3064.1
	S	1.8790	6.8027	.....	6.9145	7.0345	7.1236	7.2078	7.2879	7.3645	7.4381
550 (155.47/428.62)	V	1.097	342.48	.....	361.60	385.19	403.55	421.59	439.38	457.00	474.48
	U	655.199	2563.3	.....	2598.0	2640.6	2673.8	2706.4	2738.6	2770.6	2802.6
	H	655.802	2751.7	.....	2796.8	2852.5	2895.7	2938.3	2980.3	3022.0	3063.5
	S	1.8970	6.7870	.....	6.8900	7.0108	7.1004	7.1849	7.2653	7.3421	7.4158
575 (157.18/430.33)	V	1.099	328.41	.....	345.20	367.90	385.54	402.85	419.92	436.81	453.56
	U	662.603	2564.8	.....	2596.6	2639.6	2672.9	2705.7	2738.0	2770.1	2802.1
	H	663.235	2753.6	.....	2795.1	2851.1	2894.6	2937.3	2979.5	3021.3	3062.9
	S	1.9142	6.7720	.....	6.8664	6.9880	7.0781	7.1630	7.2436	7.3206	7.3945
600 (158.84/431.99)	V	1.101	315.47	.....	330.16	352.04	369.03	385.68	402.08	418.31	434.39
	U	669.762	2566.2	.....	2595.3	2638.5	2672.1	2705.0	2737.4	2769.6	2801.6
	H	670.423	2755.5	.....	2793.3	2849.7	2893.5	2936.4	2978.7	3020.6	3062.3
	S	1.9308	6.7575	.....	6.8437	6.9662	7.0567	7.1419	7.2228	7.3000	7.3740
625 (160.44/433.59)	V	1.103	303.54	.....	316.31	337.45	353.83	369.87	385.67	401.28	416.75
	U	676.695	2567.5	.....	2593.9	2637.5	2671.2	2704.2	2736.8	2769.1	2801.2
	H	677.384	2757.2	.....	2791.6	2848.4	2892.3	2935.4	2977.8	3019.9	3061.7
	S	1.9469	6.7437	.....	6.8217	6.9451	7.0361	7.1217	7.2028	7.2802	7.3544
650 (161.99/435.14)	V	1.105	292.49	.....	303.53	323.98	339.80	355.29	370.52	385.56	400.47
	U	683.417	2568.7	.....	2592.5	2636.4	2670.3	2703.5	2736.2	2768.5	2800.7
	H	684.135	2758.9	.....	2789.8	2847.0	2891.2	2934.4	2977.0	3019.2	3061.0
	S	1.9623	6.7304	.....	6.8004	6.9247	7.0162	7.1021	7.1835	7.2611	7.3355
675 (163.49/436.64)	V	1.106	282.23	.....	291.69	311.51	326.81	341.78	356.49	371.01	385.39
	U	689.943	2570.0	.....	2591.1	2635.4	2669.5	2702.8	2735.6	2768.0	2800.3
	H	690.689	2760.5	.....	2788.0	2845.6	2890.1	2933.5	2976.2	3018.5	3060.4
	S	1.9773	6.7176	.....	6.7798	6.9050	6.9970	7.0833	7.1650	7.2428	7.3173
700 (164.96/438.11)	V	1.108	272.68	.....	280.69	299.92	314.75	329.23	343.46	357.50	371.39
	U	696.285	2571.1	.....	2589.7	2634.3	2668.6	2702.1	2735.0	2767.5	2799.8
	H	697.061	2762.0	.....	2786.2	2844.2	2888.9	2932.5	2975.4	3017.7	3059.8
	S	1.9923	6.7052	.....	6.7598	6.8859	6.9784	7.0651	7.1470	7.2250	7.2997