

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT  
TEST -1 EXAMINATION- 2024

B.Tech-VIII Semester (BT)

MAX. MARKS: 15

COURSE CODE(CREDITS):21B1WBT831

COURSE NAME:Food Processing and Engineering

MAX. TIME: 1 Hour

COURSE INSTRUCTORS:Dr. Anil Kant

Note: (a) All questions are compulsory.

(b) Marks are indicated against each question in square brackets.

(c) The candidate is allowed to make Suitable numeric assumptions, and use water steam tables wherever required for solving problems.

Q.1

- a. Write a detailed note on food processing and technology covering following aspects i) Concept, Origin and historical perspectives ii) Importance of food processing iii) Level of food processing iv) Food Technology vs Catering Technology [4]
- b. Interpret the concept and subject matter of Food Engineering? What are unit operations? Enlist some important unit operations pertaining to the food industry. [2]

Q.3

Write a detailed note on the importance of steam as a source of heat in the food processing industry. [3]

Q.3

- a. Let a steam collection drum of  $10 \text{ m}^3$  capacity of boiler is to be filled with steam at pressure  $1.5 \text{ MN/m}^2$ . Calculate amount of heat to be supplied to water at saturation temperature (Given enthalpy of saturated water at 1 atmospheric pressure is  $417 \text{ kJ/Kg}$ ). [4]
- b. Calculate the amount of heat needed to be supplied to super heat 20 kg steam from  $128 \text{ C}$  to  $150 \text{ C}$ . [2]

P.T.O

# 1A

## Properties of Saturated Water and Steam

Temperature <i>t</i> , °C	Saturation pressure <i>p</i> , kN/m <sup>2</sup>	Density <i>ρ</i> , kg/m <sup>3</sup>		Specific volume <i>v</i> , m <sup>3</sup> /kg		Specific heat capacity <i>C<sub>p</sub></i> , kJ/kg K		Viscosity <i>μ</i> , mNs/m <sup>2</sup>		Thermal conductivity <i>k</i> , W/mK		Prandtl number <i>N<sub>Pr</sub></i> ( <i>C<sub>p</sub></i> <i>μ</i> / <i>k</i> ) dimensionless		Surface tension <i>σ</i> , mN/m	Volume expansion coefficient <i>β</i> , K <sup>-1</sup> Water	Compressi- bility <i>k</i> , bar <sup>-1</sup>
		Water	Steam	Water	Steam	Water	Steam	Water	Steam	Water	Steam	Water	Steam			
		0.01	0.611	1000	0.00485	0.00100	206.2	4.217	1.854	1.755	0.0088	0.569	0.0173			
10	1.227	1000	0.00940	0.00100	106.4	4.193	1.860	1.301	0.0091	0.587	0.0185	9.29	0.915	74.2	0.088 × 10 <sup>-3</sup>	47.89 × 10 <sup>-6</sup>
20	2.34	998	0.0173	0.00100	57.8	4.182	1.866	1.002	0.0094	0.603	0.0191	6.95	0.918	72.8	0.207 × 10 <sup>-3</sup>	45.91 × 10 <sup>-6</sup>
30	4.24	996	0.0304	0.00100	32.9	4.179	1.875	0.797	0.0097	0.618	0.0198	5.39	0.923	71.2	0.303 × 10 <sup>-3</sup>	44.73 × 10 <sup>-6</sup>
40	7.38	992	0.0513	0.00101	19.5	4.179	1.885	0.651	0.0101	0.632	0.0204	4.31	0.930	69.6	0.385 × 10 <sup>-3</sup>	44.22 × 10 <sup>-6</sup>
50	12.34	988	0.083	0.00101	12.05	4.181	1.899	0.544	0.0104	0.643	0.0210	3.53	0.939	67.9	0.458 × 10 <sup>-3</sup>	44.17 × 10 <sup>-6</sup>
60	19.92	983	0.130	0.00102	7.68	4.185	1.915	0.462	0.0107	0.653	0.0217	2.96	0.947	66.2	0.523 × 10 <sup>-3</sup>	44.50 × 10 <sup>-6</sup>
70	31.16	978	0.198	0.00102	5.05	4.190	1.936	0.400	0.0111	0.662	0.0224	2.53	0.956	64.4	0.584 × 10 <sup>-3</sup>	45.15 × 10 <sup>-6</sup>
80	47.36	972	0.293	0.00103	3.41	4.197	1.962	0.350	0.0114	0.670	0.0231	2.19	0.966	62.6	0.641 × 10 <sup>-3</sup>	46.10 × 10 <sup>-6</sup>
90	70.11	965	0.423	0.00104	2.36	4.205	1.992	0.311	0.0117	0.676	0.0240	1.93	0.976	60.7	0.696 × 10 <sup>-3</sup>	47.34 × 10 <sup>-6</sup>
100	101.3	958	0.598	0.00104	1.673	4.216	2.028	0.278	0.0121	0.681	0.0249	1.723	0.986	58.9	0.750 × 10 <sup>-3</sup>	48.90 × 10 <sup>-6</sup>
125	232.1	939	1.30	0.00107	0.770	4.254	2.147	0.219	0.0133	0.687	0.0272	1.358	1.047	-	-	-
150	476.0	917	2.55	0.00109	0.392	4.310	2.314	0.180	0.0144	0.687	0.0300	1.133	1.110	-	-	-
175	922.7	893	4.60	0.00112	0.217	4.389	2.542	0.153	0.0156	0.679	0.0334	0.990	1.185	-	-	-
200	1555.0	869	7.87	0.00116	0.127	4.497	2.843	0.133	0.0167	0.665	0.0375	0.902	1.270	-	-	-
225	2530	833	12.80	0.00120	0.0783	4.648	3.238	0.1182	0.0179	0.644	0.0427	0.853	1.36	-	-	-
250	3978	800	20.00	0.00125	0.0500	4.867	3.772	0.1065	0.0191	0.616	0.0495	0.841	1.43	-	-	-
275	5949	758	36.60	0.00132	0.0327	5.202	4.561	0.0972	0.0202	0.582	0.0587	0.869	1.56	-	-	-
300	8592	712	46.30	0.00140	0.0216	5.762	5.863	0.0897	0.0214	0.541	0.0719	0.955	1.74	-	-	-

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Temperature <i>t</i> , °C	Saturation pressure <i>p</i> , kN/m <sup>2</sup>	Density <i>ρ</i> , kg/m <sup>3</sup>		Specific volume <i>v</i> , m <sup>3</sup> /kg		Specific heat capacity <i>C<sub>p</sub></i> , kJ/kg K		Viscosity <i>μ</i> , mNs/m <sup>2</sup>		Thermal conductivity <i>k</i> , W/mK		Prandtl number <i>N<sub>Pr</sub></i> ( <i>C<sub>p</sub></i> <i>μ</i> / <i>k</i> ) dimensionless		Surface tension <i>σ</i> , mN/m	Volume expansion coefficient <i>β</i> , K <sup>-1</sup> Water	Compressi- bility <i>k</i> , bar <sup>-1</sup>
		Water	Steam	Water	Steam	Water	Steam	Water	Steam	Water	Steam	Water	Steam			
		325	12060	654	70.40	0.00153	0.0142	6.861	8.440	0.0790	0.0230	0.493	0.0929			
350	16530	575	114	0.00174	0.0088	10.10	17.15	0.0648	0.0258	0.437	0.1343	1.50	3.29	-	-	-
360	18670	528	144	0.00190	0.0019	14.60	25.10	0.0582	0.0275	0.400	0.168	2.11	3.89	-	-	-
374.2	22120	315	315	0.00317	0.0031	∞	∞	0.0450	0.0450	0.240	0.240	-	-	-	-	-

<sup>1</sup>The volume expansion coefficient, *b*, for water is at 101.3 kN/m<sup>2</sup> (1 atmosphere)

Source: Adapted from Chandrasekharan, K.D. and Venkateswarlu, D. (1974), *SI Units in Chem. Engg. Tech.*, Chem. Engg. Education Dev. Centre, IIT Madras.

# Properties of Saturated Steam at Different Temperatures

Temperature $t, ^\circ\text{C}$	Pressure $p, \text{bar}$	Specific volume $v, \text{m}^3/\text{kg}$		Specific enthalpy, $\text{kJ/kg}$		Specific entropy, $\text{kJ/kg K}$	
		$v_f, \text{m}^3/\text{kg}$	$v_g, \text{m}^3/\text{kg}$	$h_f$	$h_g$	$s_f$	$s_g$
0	0.00611	0.0010002	206.2	-0.04	2501.6	-0.0002	9.1577
2	0.00706	0.0010001	179.9	8.39	2505.2	0.0306	9.1047
4	0.00813	0.0010000	157.3	16.80	2508.9	0.0611	9.0526
6	0.00935	0.0010000	137.8	25.21	2512.6	0.0913	9.0015
8	0.01072	0.0010001	121.0	33.60	2516.2	0.1213	8.9513
10	0.00123	0.0010003	106.4	41.99	2519.9	0.1510	8.9013
15	0.01704	0.0010008	77.98	62.94	2529.1	0.2243	8.7826
20	0.0237	0.0010017	57.84	83.86	2538.2	0.2963	8.6684
25	0.03166	0.0010029	43.40	101.77	2547.3	0.3670	8.5592
30	0.04241	0.0010043	32.93	125.66	2556.4	0.4365	8.4546
35	0.05622	0.0010060	25.24	146.56	2565.4	0.5049	8.3543
40	0.07375	0.0010078	19.55	167.45	2574.4	0.5721	8.2583
45	0.09582	0.0010099	15.28	188.35	2583.3	0.6383	8.1776
50	0.12335	0.0010121	12.05	209.26	2592.2	0.7035	8.0776
55	0.15741	0.0010145	9.579	230.17	2601.0	0.7677	7.9926
60	0.19920	0.0010171	7.679	251.09	2609.7	0.8310	7.9108
65	0.2501	0.0010199	6.202	272.02	2618.4	0.8933	7.8322
70	0.3116	0.0010228	5.046	292.97	2626.9	0.9548	7.7565
75	0.3855	0.0010259	4.143	313.94	2635.4	1.0154	7.6835
80	0.4736	0.0010292	3.409	334.92	2643.8	1.10753	7.6132
85	0.5780	0.0010326	2.829	355.92	2652.0	1.1343	7.5454
90	0.7011	0.0010361	2.361	376.94	2660.1	1.1925	7.4799
95	0.8453	0.0010399	1.982	397.99	2668.1	1.2501	7.4166
100	1.0133	0.0010437	1.673	419.06	2676.0	1.3069	7.3554
105	1.2080	0.0010477	1.419	440.17	2683.7	1.3630	7.2962
110	1.4327	0.0010519	1.210	461.32	2693.0	1.4185	7.2388

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588 Appendix 1B: Properties of Saturated Steam at Different Temperatures

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Temperature <i>t</i> , °C	Pressure <i>p</i> , bar	Specific volume <i>v</i> , m <sup>3</sup> /kg		Specific enthalpy, kJ/kg		Specific entropy, kJ/kg K	
		<i>v<sub>l</sub></i> , m <sup>3</sup> /kg	<i>v<sub>g</sub></i> , m <sup>3</sup> /kg	<i>h<sub>l</sub></i>	<i>h<sub>g</sub></i>	<i>s<sub>l</sub></i>	<i>s<sub>g</sub></i>
115	1.6906	0.0010562	1.036	482.50	2698.7	1.4733	7.1832
120	1.9854	0.0010606	0.8915	503.72	2706.0	1.5276	7.1293
125	2.3210	0.0010652	0.7702	524.99	2719.9	1.5813	7.0769
130	2.7013	0.0010700	0.6681	546.31	2719.9	1.6344	7.0261
135	3.131	0.0010750	0.5818	567.68	2726.6	1.6869	6.9766
140	3.614	0.0010801	0.5085	589.10	2733.1	1.7390	6.9284
145	4.155	0.0010853	0.4460	610.60	2739.3	1.7906	6.8815
150	4.760	0.0010908	0.3924	632.15	2745.4	1.8416	6.8358
155	5.433	0.0010964	0.3464	653.78	2751.2	1.8923	6.7911
160	6.181	0.0011022	0.3068	675.47	2756.7	1.9425	6.7475
165	7.008	0.0011082	0.2724	697.25	2762.0	1.9925	6.7075
170	7.920	0.0011145	0.2426	719.12	2767.1	2.0416	6.6630
175	8.924	0.0011209	0.2165	741.07	2771.8	2.0906	6.6221
180	10.027	0.0011275	0.1938	763.12	2776.3	2.1393	6.5819
185	11.233	0.0011344	0.1739	785.26	2780.4	2.1876	6.5424
190	12.551	0.0011415	0.1563	807.52	2784.3	2.2356	6.5036
195	13.987	0.0011489	0.1408	829.88	2787.8	2.2830	6.4654
200	15.549	0.0011565	0.1272	852.37	2790.9	2.3307	6.4278
205	17.243	0.0011644	0.1150	874.99	2793.8	2.3778	6.3906
210	19.077	0.0011726	0.1042	897.74	2796.2	2.4247	6.3539
215	21.060	0.0011811	0.09463	920.63	2798.3	2.4713	6.3176
220	23.198	0.0011900	0.08604	943.67	2799.9	2.5178	6.2817
225	25.501	0.0011992	0.07835	966.89	2801.2	2.5641	6.2461
230	27.976	0.0012087	0.07145	990.26	2802.0	2.6102	6.2107

Source: *Steam Tables: Thermodynamic Properties of Water including Vapour Liquid and Solid Phases Metric Units*, Keenan, J.H., Keyes, F.G., Hill, P.G. and Moore, J.G. Copyright (1969); Reprinted with permission of John Wiley and Sons, Inc.

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