ELIZADE UNIVERSITY, ILARA-MOKIN,
ONDO STATE, NIGERIA

DEPARTMENT OF
MECHANICAL, AUTOMOTIVE AND PRODUCTION ENGINEERING

SECOND SEMESTER EXAMINATIONS

2016/2017 ACADEMIC SESSION

COURSE: MEE 302 - Thermodynamics (3 Units)

CLASS: 300 Level Mechanical and Automotive Engineering

TIME ALLOWED: 3 Hours

INSTRUCTIONS: Attempt any five questions

HOD'S SIGNATURE

Date: July/August, 2017

Question 1

(a) (i) What is the back work ratio?

(ii) Which is higher, the back work ratio for a steam-turbine or gas-turbine engine? Explain

(2 marks)

(b) A gas-turbine power plant operating on an Ideal Brayton cycle has a pressure ratio, r_p, of 8. The gas temperature is 300 K at the compressor inlet and 1300 K at the turbine inlet. Utilizing the air-standard assumptions determine (A) the back work ratio, (B) the thermal efficiency, and (C) the turbine exit temperature **(6 marks)**

Taking the compressor efficiency to be 80% and turbine efficiency to be 85% for the Brayton cycle above. Determine (a) the back work ratio, and (b) the thermal efficiency, and (C) the turbine exit temperature.

Compare and discuss the two different scenarios

(4 marks)

Question 2

(a) How do the inefficiencies of the turbine and the compressor affect the

(i) back work ratio and the (ii) thermal efficiency of a gas turbine engine. **(1 mark)**

(b) (i) How does regeneration affect the efficiency of a Brayton cycle?

(ii) Is the claim that at very high pressure ratio the thermal efficiency of Brayton cycle decreases with regeneration true? Explain **(3 marks)**

(c) (i) State two areas of application for gas-turbine engines

(ii) In an ideal regenerator, the air leaving the compressor is heated to ------------------

(iii) In an ideal gas-turbine with intercooling, reheating, and regeneration, as the number of compression and expansion stages is increased, the cycle thermal efficiency approaches

(3 marks)

(d) (i) State the general principle behind increasing the efficiency of a Rankine cycle

(ii) Explain briefly the methods by which this is achieved in increasing the Rankine cycle efficiency **(5 marks)**

Question 3

(a) What is the purpose of reheating in an ideal Rankine cycle? **(1 mark)**

(b) Is it possible to maintain a pressure of 10 kPa in a condenser that is being cooled by river water entering at 20 °C? Explain **(2 marks)**

(c) Consider a steam power plant operating on the ideal Rankine cycle. Steam enters the turbine at 3 MPa and 350 ^{0}C and is condensed in the condenser at a pressure of 10 kPa. Determine

(i) the thermal efficiency of this power plant,

(ii) the thermal efficiency if steam is superheated to 600 ^{0}C instead of 350 ^{0}C, and

(iii) the thermal efficiency if the boiler pressure is raised to 15 MPa while the turbine inlet temperature is maintained at 600 ^{0}C

(9 marks)

Question 4

(a) (i) Why is the Reversed Carnot cycle executed within the saturation dome not a realistic model for refrigeration cycles?

(ii) How do ideal vapour-compression refrigeration cycles differ from the actual ones?

(3 marks)

(b) Mention the two critical factors to be considered in refrigerant selection and any other four factors.

(2 marks)

(c) Refiregrant-134a is the working fluid in an ideal vapour-compression refrigeration cycle. The refrigerant leaves the evaporator at -20 °C and has a condenser pressure of 0.9 MPa. The mass flow rate is 3 kg/min. Find the (i) COP_R and (ii) $COP_{R,Carnot}$ for the same T_{max} and T_{min} and (iii) power input for the ideal refrigeration cycle. **(7 marks)**

Question 5

(a) (i) List four other types of refrigeration systems other than the vapour-compression refrigeration.

(ii) What is the difference between

(A) dry air and atmospheric air? And

(B) specific humidity and relative humidity? **(4 marks)**

(b) (i) What is the dew-point temperature

(ii) On a hot afternoon, the outer surface of a glass of iced-cold water "sweats". How can you explain this sweating? **(3 marks)**

(c) (i) List four different air-conditioning processes.

(ii) How do relative and specific humidities change during heating process? **(3 marks)**

(d) The interior of a moving car was at 25 °C and 70 percent relative humidity and suddenly it started to rain. At what windshield temperature will the moisture in the air start condensing on the inner surface of the windshield? **(2 marks)**

Question 6

(a) (i) Why do we study the Carnot cycle even though it is not a realistic model for gas-cycles

(ii)How does the thermal efficiency of an ideal cycle, in general, compare to that of a Carnot cycle operating between the same temperature limits **(4 marks)**

(b) A simple ideal Brayton cycle with air as the working fluid has a pressure ratio of 10. The air enters the compressor at 295 K and the turbine at 1240 K. Accounting for the variation of specific heats with temperature, determine the

(i) air temperature at the compressor exit,

(ii) back work ratio, and

(iii) thermal efficiency **(8 marks)**

Question 7

(a) (i) Mention two critical factors that affect the human comfort in living space?

(ii) A room $5\,m \times 5\,m \times 5\,m$room contains air at 25 °C and 100 kPa at a relative humidity of 75 percent. Determine (a) the partial pressure of dry air, (b) the specific humidity, (c) the enthalpy per unit mass of the dry air, and (d) the masses of the dry air and water vapour in the room

(5 marks)

(b) Refrigerant-134a enters the compressor of a refrigerator as superheated vapour at 0.14 MPa and -10 °C at a rate of 0.05 kg/s and leaves at 0.8 MPa and 50 °C. The refrigerant is cooled in the condenser to 27 °C and 0.72 MPa and is throttled to 0.15 MPa. Disregarding any heat transfer and pressure drops in the connecting lines between the components, determine the

(i) rate of heat removal from the refrigerated space

(ii) power input to the compressor,

(iii) isentropic efficiency of the compressor, and

(iv) COP of the refrigerator. **(7 marks)**

89.26

SELECTED RELEVANT FORMULAS

1. $\frac{P_{r_2}}{P_{r_1}} = \frac{P_2}{P_1}$

2. $\eta_C = \frac{w_s}{w_a}$

3. $\eta_T = \frac{w_a}{w_s}$

4. $\eta_{th} = \frac{w_{net}}{q_{in}}$ or $\eta_{th} = 1 - \frac{q_{out}}{q_{in}}$

5. $(q_{in} - q_{out}) + (w_{in} - w_{out}) = h_e - h_i$

6. $w_{pump,in} = v(P_2 - P_1)$

7. $\dot{W} = \dot{m}(\Delta h)$

8. $\phi = \frac{P_v}{P_g}$

9. $\omega = \frac{0.622 P_v}{P - P_v}$

10. $COP_R = \frac{q_L}{w_{in}}$

11. $COP_{R,Carnot} = \frac{1}{(T_H/T_L) - 1}$

12202.83125

TABLE A–17

Ideal-gas properties of air

T K	h kJ/kg	P_r	u kJ/kg	v_r	s° kJ/kg·K	T K	h kJ/kg	P_r	u kJ/kg	v_r	s° kJ/kg·K
290	290.16	1.2311	206.91	676.1	1.66802	680	691.82	25.85	496.62	75.50	2.54175
295	295.17	1.3068	210.49	647.9	1.68515	690	702.52	27.29	504.45	72.56	2.55731
298	298.18	1.3543	212.64	631.9	1.69528	700	713.27	28.80	512.33	69.76	2.57277
300	300.19	1.3860	214.07	621.2	1.70203	710	724.04	30.38	520.23	67.07	2.58810
305	305.22	1.4686	217.67	596.0	1.71865	720	734.82	32.02	528.14	64.53	2.60319
310	310.24	1.5546	221.25	572.3	1.73498	730	745.62	33.72	536.07	62.13	2.61803
315	315.27	1.6442	224.85	549.8	1.75106	740	756.44	35.50	544.02	59.82	2.63280
320	320.29	1.7375	228.42	528.6	1.76690	750	767.29	37.35	551.99	57.63	2.64737
325	325.31	1.8345	232.02	508.4	1.78249	760	778.18	39.27	560.01	55.54	2.66176
330	330.34	1.9352	235.61	489.4	1.79783	780	800.03	43.35	576.12	51.64	2.69013
340	340.42	2.149	242.82	454.1	1.82790	800	821.95	47.75	592.30	48.08	2.71787
350	350.49	2.379	250.02	422.2	1.85708	820	843.98	52.59	608.59	44.84	2.74504
360	360.58	2.626	257.24	393.4	1.88543	840	866.08	57.60	624.95	41.85	2.77170
370	370.67	2.892	264.46	367.2	1.91313	860	888.27	63.09	641.40	39.12	2.79783
380	380.77	3.176	271.69	343.4	1.94001	880	910.56	68.98	657.95	36.61	2.82344
390	390.88	3.481	278.93	321.5	1.96633	900	932.93	75.29	674.58	34.31	2.84856
400	400.98	3.806	286.16	301.6	1.99194	920	955.38	82.05	691.28	32.18	2.87324
410	411.12	4.153	293.43	283.3	2.01699	940	977.92	89.28	708.08	30.22	2.89748
420	421.26	4.522	300.69	266.6	2.04142	960	1000.55	97.00	725.02	28.40	2.92128
430	431.43	4.915	307.99	251.1	2.06533	980	1023.25	105.2	741.98	26.73	2.94468
440	441.61	5.332	315.30	236.8	2.08870	1000	1046.04	114.0	758.94	25.17	2.96770
450	451.80	5.775	322.62	223.6	2.11161	1020	1068.89	123.4	776.10	23.72	2.99034
460	462.02	6.245	329.97	211.4	2.13407	1040	1091.85	133.3	793.36	23.29	3.01260
470	472.24	6.742	337.32	200.1	2.15604	1060	1114.86	143.9	810.62	21.14	3.03449
480	482.49	7.268	344.70	189.5	2.17760	1080	1137.89	155.2	827.88	19.98	3.05608
490	492.74	7.824	352.08	179.7	2.19876	1100	1161.07	167.1	845.33	18.896	3.07732
500	503.02	8.411	359.49	170.6	2.21952	1120	1184.28	179.7	862.79	17.886	3.09825
510	513.32	9.031	366.92	162.1	2.23993	1140	1207.57	193.1	880.35	16.946	3.11883
520	523.63	9.684	374.36	154.1	2.25997	1160	1230.92	207.2	897.91	16.064	3.13916
530	533.98	10.37	381.84	146.7	2.27967	1180	1254.34	222.2	915.57	15.241	3.15916
540	544.35	11.10	389.34	139.7	2.29906	1200	1277.79	238.0	933.33	14.470	3.17888
550	555.74	11.86	396.86	133.1	2.31809	1220	1301.31	254.7	951.09	13.747	3.19834
560	565.17	12.66	404.42	127.0	2.33685	1240	1324.93	272.3	968.95	13.069	3.21751
570	575.59	13.50	411.97	121.2	2.35531						
1260	1348.55	290.8	986.90	12.435	3.23638	1600	1757.57	791.2	1298.30	5.804	3.52364
1280	1372.24	310.4	1004.76	11.835	3.25510	1620	1782.00	834.1	1316.96	5.574	3.53879
1300	1395.97	330.9	1022.82	11.275	3.27345	1640	1806.46	878.9	1335.72	5.355	3.55381
1320	1419.76	352.5	1040.88	10.747	3.29160	1660	1830.96	925.6	1354.48	5.147	3.56867
1340	1443.60	375.3	1058.94	10.247	3.30959	1680	1855.50	974.2	1373.24	4.949	3.58335
1360	1467.49	399.1	1077.10	9.780	3.32724	1700	1880.1	1025	1392.7	4.761	3.5979
1380	1491.44	424.2	1095.26	9.337	3.34474	1750	1941.6	1161	1439.8	4.328	3.6336
1400	1515.42	450.5	1113.52	8.919	3.36200	1800	2003.3	1310	1487.2	3.994	3.6684
1420	1539.44	478.0	1131.77	8.526	3.37901	1850	2065.3	1475	1534.9	3.601	3.7023

0.287

21.85

mv = PvV / 0.4654 x 298 / 2.37735 x 125

4.08 / 20 = 2.09

4.08T4 = 3100

297.168 / 138.6692

924.8

TABLE A–5

Saturated water—Pressure table

Press., P kPa	Sat. temp., T_{sat} °C	Specific volume, m³/kg: Sat. liquid, v_f	Sat. vapor, v_g	Internal energy, kJ/kg: Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Enthalpy, kJ/kg: Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Entropy, kJ/kg·K: Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
1.0	6.97	0.001000	129.19	29.302	2355.2	2384.5	29.303	2484.4	2513.7	0.1059	8.8690	8.9749
1.5	13.02	0.001001	87.964	54.686	2338.1	2392.8	54.688	2470.1	2524.7	0.1956	8.6314	8.8270
2.0	17.50	0.001001	66.990	73.431	2325.5	2398.9	73.433	2459.5	2532.9	0.2606	8.4621	8.7227
2.5	21.08	0.001002	54.242	88.422	2315.4	2403.8	88.424	2451.0	2539.4	0.3118	8.3302	8.6421
3.0	24.08	0.001003	45.654	100.98	2306.9	2407.9	100.98	2443.9	2544.8	0.3543	8.2222	8.5765
4.0	28.96	0.001004	34.791	121.39	2293.1	2414.5	121.39	2432.3	2553.7	0.4224	8.0510	8.4734
5.0	32.87	0.001005	28.185	137.75	2282.1	2419.8	137.75	2423.0	2560.7	0.4762	7.9176	8.3938
7.5	40.29	0.001008	19.233	168.74	2261.1	2429.8	168.75	2405.3	2574.0	0.5763	7.6738	8.2501
10	45.81	0.001010	14.670	191.79	2245.4	2437.2	191.81	2392.1	2583.9	0.6492	7.4996	8.1488
15	53.97	0.001014	10.020	225.93	2222.1	2448.0	225.94	2372.3	2598.3	0.7549	7.2522	8.0071
20	60.06	0.001017	7.6481	251.40	2204.6	2456.0	251.42	2357.5	2608.9	0.8320	7.0752	7.9073
25	64.96	0.001020	6.2034	271.93	2190.4	2462.4	271.96	2345.5	2617.5	0.8932	6.9370	7.8302
30	69.09	0.001022	5.2287	289.24	2178.5	2467.7	289.27	2335.3	2624.6	0.9441	6.8234	7.7675
40	75.86	0.001026	3.9933	317.58	2158.8	2476.3	317.62	2318.4	2636.1	1.0261	6.6430	7.6691
50	81.32	0.001030	3.2403	340.49	2142.7	2483.2	340.54	2304.7	2645.2	1.0912	6.5019	7.5931
75	91.76	0.001037	2.2172	384.36	2111.8	2496.1	384.44	2278.0	2662.4	1.2132	6.2426	7.4558
100	99.61	0.001043	1.6941	417.40	2088.2	2505.6	417.51	2257.5	2675.0	1.3028	6.0562	7.3589
101.325	99.97	0.001043	1.6734	418.95	2087.0	2506.0	419.06	2256.5	2675.6	1.3069	6.0476	7.3545
125	105.97	0.001048	1.3750	444.23	2068.8	2513.0	444.36	2240.6	2684.9	1.3741	5.9100	7.2841
150	111.35	0.001053	1.1594	466.97	2052.3	2519.2	467.13	2226.0	2693.1	1.4337	5.7894	7.2231
175	116.04	0.001057	1.0037	486.82	2037.7	2524.5	487.01	2213.1	2700.2	1.4850	5.6865	7.1716
200	120.21	0.001061	0.88578	504.50	2024.6	2529.1	504.71	2201.6	2706.3	1.5302	5.5968	7.1270
225	123.97	0.001064	0.79329	520.47	2012.7	2533.2	520.71	2191.0	2711.7	1.5706	5.5171	7.0877
250	127.41	0.001067	0.71873	535.08	2001.8	2536.8	535.35	2181.2	2716.5	1.6072	5.4453	7.0525
275	130.58	0.001070	0.65732	548.57	1991.6	2540.1	548.86	2172.0	2720.9	1.6408	5.3800	7.0207
300	133.52	0.001073	0.60582	561.11	1982.1	2543.2	561.43	2163.5	2724.9	1.6717	5.3200	6.9917
325	136.27	0.001076	0.56199	572.84	1973.1	2545.9	573.19	2155.4	2728.6	1.7005	5.2645	6.9650
350	138.86	0.001079	0.52422	583.89	1964.6	2548.5	584.26	2147.7	2732.0	1.7274	5.2128	6.9402
375	141.30	0.001081	0.49133	594.32	1956.6	2550.9	594.73	2140.4	2735.1	1.7526	5.1645	6.9171
400	143.61	0.001084	0.46242	604.22	1948.9	2553.1	604.66	2133.4	2738.1	1.7765	5.1191	6.8955

TABLE A–6

Superheated water (*Concluded*)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 2.50 MPa (223.95°C)				P = 3.00 MPa (233.85°C)			
Sat.	0.07995	2602.1	2801.9	6.2558	0.06667	2603.2	2803.2	6.1856
225	0.08026	2604.8	2805.5	6.2629				
250	0.08705	2663.3	2880.9	6.4107	0.07063	2644.7	2856.5	6.2893
300	0.09894	2762.2	3009.6	6.6459	0.08118	2750.8	2994.3	6.5412
350	0.10979	2852.5	3127.0	6.8424	0.09056	2844.4	3116.1	6.7450
400	0.12012	2939.8	3240.1	7.0170	0.09938	2933.6	3231.7	6.9235
450	0.13015	3026.2	3351.6	7.1768	0.10789	3021.2	3344.9	7.0856
500	0.13999	3112.8	3462.8	7.3254	0.11620	3108.6	3457.2	7.2359
600	0.15931	3288.5	3686.8	7.5979	0.13245	3285.5	3682.8	7.5103
700	0.17835	3469.3	3915.2	7.8455	0.14841	3467.0	3912.2	7.7590
800	0.19722	3656.2	4149.2	8.0744	0.16420	3654.3	4146.9	7.9885
900	0.21597	3849.4	4389.3	8.2882	0.17988	3847.9	4387.5	8.2028
1000	0.23466	4049.0	4635.6	8.4897	0.19549	4047.7	4634.2	8.4045
1100	0.25330	4254.7	4887.9	8.6804	0.21105	4253.6	4886.7	8.5955
1200	0.27190	4466.3	5146.0	8.8618	0.22658	4465.3	5145.1	8.7771
1300	0.29048	4683.4	5409.5	9.0349	0.24207	4682.6	5408.8	8.9502

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 15.0 MPa (342.16°C)			
Sat.	0.010341	2455.7	2610.8	5.3108
350	0.011481	2520.9	2693.1	5.4438
400	0.015671	2740.6	2975.7	5.8819
450	0.018477	2880.8	3157.9	6.1434
500	0.020828	2998.4	3310.8	6.3480
550	0.022945	3106.2	3450.4	6.5230
600	0.024921	3209.3	3583.1	6.6796
650	0.026804	3310.1	3712.1	6.8233
700	0.028621	3409.8	3839.1	6.9573
800	0.032121	3609.3	4091.1	7.2037
900	0.035503	3811.2	4343.7	7.4288
1000	0.038808	4017.1	4599.2	7.6378
1100	0.042062	4227.7	4858.6	7.8339
1200	0.045279	4443.1	5122.3	8.0192
1300	0.048469	4663.3	5390.3	8.1952

Saturated refrigerant-134a—Temperature table

Temp., T °C	Sat. press., P_{sat} kPa	Specific volume, m³/kg: Sat. liquid, v_f	Sat. vapor, v_g	Internal energy, kJ/kg: Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Enthalpy, kJ/kg: Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Entropy, kJ/kg·K: Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
−40	51.25	0.0007054	0.36081	−0.036	207.40	207.37	0.000	225.86	225.86	0.00000	0.96866	0.96866
−38	56.86	0.0007083	0.32732	2.475	206.04	208.51	2.516	224.61	227.12	0.01072	0.95511	0.96584
−36	62.95	0.0007112	0.29751	4.992	204.67	209.66	5.037	223.35	228.39	0.02138	0.94176	0.96315
−34	69.56	0.0007142	0.27090	7.517	203.29	210.81	7.566	222.09	229.65	0.03199	0.92859	0.96058
−32	76.71	0.0007172	0.24711	10.05	201.91	211.96	10.10	220.81	230.91	0.04253	0.91560	0.95813
−30	84.43	0.0007203	0.22580	12.59	200.52	213.11	12.65	219.52	232.17	0.05301	0.90278	0.95579
−28	92.76	0.0007234	0.20666	15.13	199.12	214.25	15.20	218.22	233.43	0.06344	0.89012	0.95356
−26	101.73	0.0007265	0.18946	17.69	197.72	215.40	17.76	216.92	234.68	0.07382	0.87762	0.95144
−24	111.37	0.0007297	0.17395	20.25	196.30	216.55	20.33	215.59	235.92	0.08414	0.86527	0.94941
−22	121.72	0.0007329	0.15995	22.82	194.88	217.70	22.91	214.26	237.17	0.09441	0.85307	0.94748
−20	132.82	0.0007362	0.14729	25.39	193.45	218.84	25.49	212.91	238.41	0.10463	0.84101	0.94564
−18	144.69	0.0007396	0.13583	27.98	192.01	219.98	28.09	211.55	239.64	0.11481	0.82908	0.94389

Saturated refrigerant-134a—Pressure table

Press., P kPa	Sat. temp., T_{sat} °C	Specific volume, m³/kg: Sat. liquid, v_f	Sat. vapor, v_g	Internal energy, kJ/kg: Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Enthalpy, kJ/kg: Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Entropy, kJ/kg·K: Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
700	26.69	0.0008331	0.029361	88.24	156.24	244.48	88.82	176.21	265.03	0.33230	0.58763	0.91994
750	29.06	0.0008395	0.027371	91.59	154.08	245.67	92.22	173.98	266.20	0.34345	0.57567	0.91912
800	31.31	0.0008458	0.025621	94.79	152.00	246.79	95.47	171.82	267.29	0.35404	0.56431	0.91835
850	33.45	0.0008520	0.024069	97.87	149.98	247.85	98.60	169.71	268.31	0.36413	0.55349	0.91762
900	35.51	0.0008580	0.022683	100.83	148.01	248.85	101.61	167.66	269.26	0.37377	0.54315	0.91692
950	37.48	0.0008641	0.021438	103.69	146.10	249.79	104.51	165.64	270.15	0.38301	0.53323	0.91624

Superheated refrigerant-134a (*Continued*)

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 0.80 MPa (T_{sat} = 31.31°C)				P = 0.90 MPa (T_{sat} = 35.51°C)				P = 1.00 MPa (T_{sat} = 39.37°C)			
Sat.	0.025621	246.79	267.29	0.9183	0.022683	248.85	269.26	0.9169	0.020313	250.68	270.99	0.9156
40	0.027035	254.82	276.45	0.9480	0.023375	253.13	274.17	0.9327	0.020406	251.30	271.71	0.9179
50	0.028547	263.86	286.69	0.9802	0.024809	262.44	284.77	0.9660	0.021796	260.94	282.74	0.9525
60	0.029973	272.83	296.81	1.0110	0.026146	271.60	295.13	0.9976	0.023068	270.32	293.38	0.9850
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Superheated refrigerant-134a

T °C	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K	v m³/kg	u kJ/kg	h kJ/kg	s kJ/kg·K
	P = 0.06 MPa (T_{sat} = −36.95°C)				P = 0.10 MPa (T_{sat} = −26.37°C)				P = 0.14 MPa (T_{sat} = −18.77°C)			
Sat.	0.31121	209.12	227.79	0.9644	0.19254	215.19	234.44	0.9518	0.14014	219.54	239.16	0.9446
−20	0.33608	220.60	240.76	1.0174	0.19841	219.66	239.50	0.9721				
−10	0.35048	227.55	248.58	1.0477	0.20743	226.75	247.49	1.0030	0.14605	225.91	246.36	0.9724
0	0.36476	234.66	256.54	1.0774	0.21630	233.95	255.58	1.0332	0.15263	233.23	254.60	1.0031
10	0.37893	241.92	264.66	1.1066	0.22506	241.30	263.81	1.0628	0.15908	240.66	262.93	1.0331

Saturated water—Temperature table

Temp., T °C	Sat. press., P_{sat} kPa	Specific volume, m³/kg: Sat. liquid, v_f	Sat. vapor, v_g	Internal energy, kJ/kg: Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Enthalpy, kJ/kg: Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Entropy, kJ/kg·K: Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
0.01	0.6117	0.001000	206.00	0.000	2374.9	2374.9	0.001	2500.9	2500.9	0.0000	9.1556	9.1556
5	0.8725	0.001000	147.03	21.019	2360.8	2381.8	21.020	2489.1	2510.1	0.0763	8.9487	9.0249
10	1.2281	0.001000	106.32	42.020	2346.6	2388.7	42.022	2477.2	2519.2	0.1511	8.7488	8.8999
15	1.7057	0.001001	77.885	62.980	2332.5	2395.5	62.982	2465.4	2528.3	0.2245	8.5559	8.7803
20	2.3392	0.001002	57.762	83.913	2318.4	2402.3	83.915	2453.5	2537.4	0.2965	8.3696	8.6661
25	3.1698	0.001003	43.340	104.83	2304.3	2409.1	104.83	2441.7	2546.5	0.3672	8.1895	8.5567
30	4.2469	0.001004	32.879	125.73	2290.2	2415.9	125.74	2429.8	2555.6	0.4368	8.0152	8.4520

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$\eta_{th} = \frac{h_{2s}-h_1}{h_2-h_1}$