

Air modeled as an ideal gas (molecular weight 28.97 kg/kmol, thermal conductivity 0.025 W/m·K, specific heat 1.025 kJ/kg·K), the universal gas constant = 8.314 kJ/kmol·K, and 0°C = 273.15 K. O₂, CO and H₂O are with molecular weight of 32 kg/kmol, 28 kg/kmol and 18 kg/kmol, respectively.

- Water mixture with a quality of 0.5 at 0.2 MPa is contained in a rigid, closed and well-isolated box with a volume of 3 m³ where the box is equipped with an internal heater. An electric power is given to the heater to transform the water mixture to a saturated vapor state. Please determine (a) the mass of water mixture, in kg, (b) the final pressure, in bar, (c) the work required by the heater, in kJ, and (d) the entropy production in the heating process, in kJ/K. (20%)
- Air is always kept at a pressure of 1 MPa and a temperature of 17°C in a huge container that is through a valve connected to a turbine followed by a rigid and closed tank with a volume of 1.5 m³. The air in the tank is initially at 1 bar and 27°C. A filling process takes place adiabatically until the air in the tank reaches 1 MPa and 23°C where the kinetic and potential energy effects can be ignored. Air behaves as an ideal gas. Please determine (a) the initial mass in tank, in kg, (b) the work developed by the turbine, in kJ, and (c) the entropy production in the filling process, in kJ/K. (15%)
- In a polytropic process with $n=1.4$ carbon monoxide with a mass of 0.45 kg along with 0.75 kg oxygen is compressed from 3 bar and 350 K to a state of 500 K. Both gases behave as an ideal gas. Please determine (a) the final pressure, in bar, (b) the work required to compress the gas mixture, in kJ, and (c) the heat transfer in the compression process, in kJ. (15%)
- Air with a volumetric flow rate of 7200 m³/hr at 40°C and a humidity ratio of 0.01 is cooled by an evaporation cooler to a temperature of 25°C where water is added to the soaked pad at 20°C and fully evaporated into the moist air. Heat transfer to the surroundings is negligible and the pressure is kept constant at 1 bar throughout the cooling process. Please determine (a) the mass flow rate of the water to the soaked pad, in kg/hr, and (b) the relative humidity of the moist air exiting the cooler. (10%)
- An ideal combined gas turbine-vapor power plant shown in Fig.1 delivers a net power output of 50 MW where the efficiency of the heat-recovery steam generator is 100%. Table 1 summarizes the pressure and temperature of the states visited by gas and water vapor. Please determine (a) T_2 , in K, (b) T_4 , in K, (c) T_6 , in K, (d) T_8 , in K, (e) the vapor flow rate, in kg/s, (f) the power of vapor turbine, in MW, (g) the rate of heat transfer to the combustor, in MW, (h) the rate of heat transfer to the cooling water, in MW. (40%)

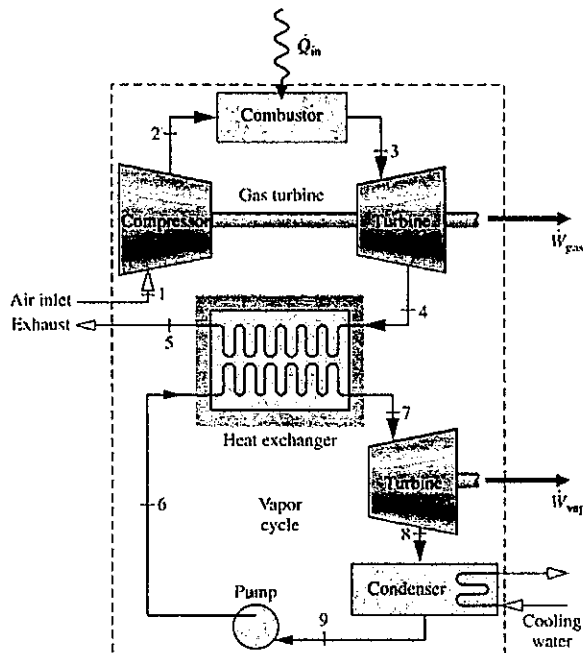


Table 1: Pressure and temperature of the states visited by gas and water vapor

| State | Pressure (bar) | Temperature (K) |
|-------|----------------|------------------|
| 1 | 1 | 290 |
| 2 | 13 | T_2 |
| 3 | 13 | 1550 |
| 4 | 1 | T_4 |
| 5 | 1 | 350 |
| 6 | 10 | T_6 |
| 7 | 10 | 500 |
| 8 | 0.1 | T_8 |
| 9 | 0.1 | Saturated Liquid |

Figure 1: An ideal combined gas turbine-vapor power plant

見背面

題號: 251

科目: 熱工學

節次: 8

國立臺灣大學 109 學年度碩士班招生考試試題

題號: 251

共 5 頁之第 2 頁

Properties of Saturated Water (Liquid-Vapor): Temperature Table

Pressure Conversions:
1 bar = 0.1 MPa
= 10⁵ kPa

| Temp. °C | Press. bar | Specific Volume m ³ /kg | | Internal Energy kJ/kg | | Enthalpy kJ/kg | | | Entropy kJ/kg · K | | Temp. °C |
|----------|------------|--|---------------------------|----------------------------|---------------------------|----------------------------|-----------------------|---------------------------|----------------------------|---------------------------|----------|
| | | Sat. Liquid u _f × 10 ³ | Sat. Vapor u _g | Sat. Liquid u _f | Sat. Vapor u _g | Sat. Liquid h _f | Evap. h _{fg} | Sat. Vapor h _g | Sat. Liquid s _f | Sat. Vapor s _g | |
| .01 | 0.00611 | 1.0002 | 206.136 | 0.00 | 2375.3 | 0.01 | 2501.3 | 2501.4 | 0.0000 | 9.1562 | .01 |
| 4 | 0.00813 | 1.0001 | 167.232 | 16.77 | 2380.9 | 16.78 | 2491.9 | 2508.7 | 0.0610 | 9.0514 | 4 |
| 5 | 0.00872 | 1.0001 | 147.120 | 20.97 | 2382.3 | 20.98 | 2489.6 | 2510.6 | 0.0761 | 9.0257 | 5 |
| 6 | 0.00935 | 1.0001 | 137.734 | 25.19 | 2383.6 | 25.20 | 2487.2 | 2512.4 | 0.0912 | 9.0003 | 6 |
| 8 | 0.01072 | 1.0002 | 120.917 | 33.59 | 2386.4 | 33.60 | 2482.5 | 2516.1 | 0.1212 | 8.9601 | 8 |
| 10 | 0.01228 | 1.0004 | 106.379 | 42.00 | 2389.2 | 42.01 | 2477.7 | 2519.8 | 0.1510 | 8.9008 | 10 |
| 11 | 0.01312 | 1.0004 | 99.857 | 46.20 | 2390.5 | 46.20 | 2475.4 | 2521.6 | 0.1658 | 8.8765 | 11 |
| 12 | 0.01402 | 1.0005 | 93.784 | 50.41 | 2391.9 | 50.41 | 2473.0 | 2523.4 | 0.1806 | 8.8524 | 12 |
| 13 | 0.01497 | 1.0007 | 88.124 | 54.60 | 2393.3 | 54.60 | 2470.7 | 2525.3 | 0.1953 | 8.8285 | 13 |
| 14 | 0.01598 | 1.0008 | 82.848 | 58.79 | 2394.7 | 58.80 | 2468.3 | 2527.1 | 0.2099 | 8.8048 | 14 |
| 15 | 0.01705 | 1.0009 | 77.926 | 62.99 | 2396.1 | 62.99 | 2465.9 | 2528.9 | 0.2245 | 8.7814 | 15 |
| 16 | 0.01818 | 1.0011 | 73.333 | 67.18 | 2397.4 | 67.19 | 2463.5 | 2530.8 | 0.2390 | 8.7582 | 16 |
| 17 | 0.01938 | 1.0012 | 69.044 | 71.38 | 2398.8 | 71.38 | 2461.2 | 2532.6 | 0.2535 | 8.7351 | 17 |
| 18 | 0.02064 | 1.0014 | 65.038 | 75.57 | 2400.2 | 75.58 | 2458.8 | 2534.4 | 0.2679 | 8.7123 | 18 |
| 19 | 0.02198 | 1.0016 | 61.293 | 79.76 | 2401.6 | 79.77 | 2456.5 | 2536.2 | 0.2823 | 8.6897 | 19 |
| 20 | 0.02339 | 1.0018 | 57.791 | 83.95 | 2403.0 | 83.96 | 2454.1 | 2538.1 | 0.2966 | 8.6672 | 20 |
| 21 | 0.02487 | 1.0020 | 54.514 | 88.14 | 2404.3 | 88.14 | 2451.8 | 2539.9 | 0.3109 | 8.6450 | 21 |
| 22 | 0.02645 | 1.0022 | 51.447 | 92.32 | 2405.7 | 92.33 | 2449.4 | 2541.7 | 0.3251 | 8.6229 | 22 |
| 23 | 0.02810 | 1.0024 | 48.574 | 96.51 | 2407.0 | 96.52 | 2447.0 | 2543.5 | 0.3393 | 8.6011 | 23 |
| 24 | 0.02985 | 1.0027 | 45.883 | 100.70 | 2408.4 | 100.70 | 2444.7 | 2545.4 | 0.3534 | 8.5794 | 24 |
| 25 | 0.03169 | 1.0029 | 43.360 | 104.88 | 2409.8 | 104.89 | 2442.3 | 2547.2 | 0.3674 | 8.5580 | 25 |
| 26 | 0.03363 | 1.0032 | 40.994 | 109.06 | 2411.1 | 109.07 | 2439.9 | 2549.0 | 0.3814 | 8.5367 | 26 |
| 27 | 0.03567 | 1.0035 | 38.774 | 113.25 | 2412.5 | 113.25 | 2437.5 | 2550.8 | 0.3954 | 8.5156 | 27 |
| 28 | 0.03782 | 1.0037 | 36.690 | 117.42 | 2413.9 | 117.43 | 2435.2 | 2552.6 | 0.4093 | 8.4946 | 28 |
| 29 | 0.04008 | 1.0040 | 34.733 | 121.60 | 2415.2 | 121.61 | 2432.8 | 2554.5 | 0.4231 | 8.4739 | 29 |
| 30 | 0.04246 | 1.0043 | 32.894 | 125.78 | 2416.6 | 125.79 | 2430.5 | 2556.3 | 0.4369 | 8.4533 | 30 |
| 31 | 0.04496 | 1.0046 | 31.165 | 129.96 | 2418.0 | 129.97 | 2428.1 | 2558.1 | 0.4507 | 8.4329 | 31 |
| 32 | 0.04759 | 1.0050 | 29.540 | 134.14 | 2419.3 | 134.15 | 2425.7 | 2559.9 | 0.4644 | 8.4127 | 32 |
| 33 | 0.05034 | 1.0053 | 28.011 | 138.32 | 2420.7 | 138.33 | 2423.3 | 2561.7 | 0.4781 | 8.3927 | 33 |
| 34 | 0.05324 | 1.0056 | 26.571 | 142.50 | 2422.0 | 142.50 | 2421.0 | 2563.5 | 0.4917 | 8.3728 | 34 |
| 35 | 0.05628 | 1.0060 | 25.216 | 146.67 | 2423.4 | 146.68 | 2418.6 | 2565.3 | 0.5053 | 8.3531 | 35 |
| 36 | 0.05947 | 1.0063 | 23.940 | 150.85 | 2424.7 | 150.86 | 2416.2 | 2567.1 | 0.5188 | 8.3336 | 36 |
| 38 | 0.06632 | 1.0071 | 21.602 | 158.20 | 2427.4 | 158.21 | 2411.5 | 2570.7 | 0.5458 | 8.2950 | 38 |
| 40 | 0.07384 | 1.0078 | 19.523 | 167.56 | 2430.1 | 167.57 | 2406.7 | 2574.3 | 0.5725 | 8.2570 | 40 |
| 45 | 0.09593 | 1.0099 | 15.258 | 188.44 | 2436.8 | 188.45 | 2394.8 | 2583.2 | 0.6387 | 8.1648 | 45 |

(Continued)

| Temp. °C | Press. bar | Specific Volume m ³ /kg | | Internal Energy kJ/kg | | Enthalpy kJ/kg | | | Entropy kJ/kg · K | | Temp. °C |
|----------|------------|--|---------------------------|----------------------------|---------------------------|----------------------------|-----------------------|---------------------------|----------------------------|---------------------------|----------|
| | | Sat. Liquid u _f × 10 ³ | Sat. Vapor u _g | Sat. Liquid u _f | Sat. Vapor u _g | Sat. Liquid h _f | Evap. h _{fg} | Sat. Vapor h _g | Sat. Liquid s _f | Sat. Vapor s _g | |
| 50 | 1.235 | 1.0121 | 12.032 | 209.32 | 2443.5 | 209.33 | 2382.7 | 2592.1 | 0.7038 | 8.0783 | 50 |
| 55 | 1.176 | 1.0148 | 9.568 | 230.21 | 2450.1 | 230.23 | 2370.7 | 2600.9 | 0.7679 | 7.9913 | 55 |
| 60 | 1.194 | 1.0172 | 7.671 | 251.11 | 2456.6 | 251.13 | 2358.5 | 2609.6 | 0.8312 | 7.9096 | 60 |
| 65 | 1.253 | 1.0199 | 6.197 | 272.02 | 2463.1 | 272.06 | 2346.2 | 2618.3 | 0.8935 | 7.8310 | 65 |
| 70 | 1.319 | 1.0228 | 5.042 | 292.95 | 2469.6 | 292.98 | 2333.8 | 2626.8 | 0.9549 | 7.7553 | 70 |
| 75 | 1.388 | 1.0259 | 4.131 | 313.90 | 2475.9 | 313.93 | 2321.4 | 2635.3 | 1.0155 | 7.6824 | 75 |
| 80 | 1.473 | 1.0291 | 3.407 | 334.86 | 2482.2 | 334.91 | 2309.0 | 2643.7 | 1.0753 | 7.6122 | 80 |
| 85 | 1.573 | 1.0325 | 2.828 | 355.84 | 2488.4 | 355.90 | 2296.6 | 2651.9 | 1.1343 | 7.5445 | 85 |
| 90 | 1.704 | 1.0360 | 2.361 | 376.85 | 2494.5 | 376.92 | 2284.2 | 2660.1 | 1.1925 | 7.4791 | 90 |
| 95 | 1.855 | 1.0397 | 1.982 | 397.88 | 2500.6 | 397.96 | 2271.7 | 2668.1 | 1.2500 | 7.4159 | 95 |
| 100 | 2.014 | 1.0435 | 1.673 | 418.94 | 2506.5 | 419.04 | 2259.2 | 2676.1 | 1.3069 | 7.3549 | 100 |
| 110 | 2.433 | 1.0516 | 1.210 | 461.14 | 2518.1 | 461.30 | 2230.2 | 2691.5 | 1.4185 | 7.2387 | 110 |
| 120 | 2.985 | 1.0603 | 0.8919 | 503.50 | 2529.3 | 503.71 | 2202.6 | 2706.3 | 1.5278 | 7.1296 | 120 |
| 130 | 3.701 | 1.0697 | 0.6685 | 546.02 | 2539.9 | 546.31 | 2174.2 | 2720.5 | 1.6344 | 7.0269 | 130 |
| 140 | 4.513 | 1.0797 | 0.5089 | 588.74 | 2550.0 | 589.13 | 2144.7 | 2733.9 | 1.7391 | 6.9299 | 140 |
| 150 | 5.478 | 1.0905 | 0.3928 | 631.68 | 2559.5 | 632.20 | 2114.3 | 2746.5 | 1.8418 | 6.8379 | 150 |
| 160 | 6.178 | 1.1020 | 0.3071 | 674.86 | 2568.4 | 675.55 | 2082.6 | 2758.1 | 1.9427 | 6.7502 | 160 |
| 170 | 7.917 | 1.1143 | 0.2428 | 718.33 | 2576.5 | 719.21 | 2049.5 | 2768.7 | 2.0419 | 6.6663 | 170 |
| 180 | 10.02 | 1.1274 | 0.1941 | 762.09 | 2583.7 | 763.22 | 2015.0 | 2778.2 | 2.1396 | 6.5857 | 180 |
| 190 | 12.54 | 1.1414 | 0.1565 | 806.19 | 2590.0 | 807.62 | 1978.8 | 2786.4 | 2.2359 | 6.5079 | 190 |
| 200 | 15.54 | 1.1565 | 0.1274 | 850.65 | 2595.3 | 852.45 | 1940.7 | 2793.2 | 2.3309 | 6.4323 | 200 |
| 210 | 19.06 | 1.1726 | 0.1044 | 895.53 | 2599.5 | 897.76 | 1900.7 | 2798.5 | 2.4248 | 6.3585 | 210 |
| 220 | 23.18 | 1.1900 | 0.08619 | 940.87 | 2602.4 | 943.62 | 1858.5 | 2802.1 | 2.5178 | 6.2861 | 220 |
| 230 | 27.96 | 1.2088 | 0.07158 | 986.74 | 2603.9 | 990.12 | 1813.8 | 2804.0 | 2.6099 | 6.2146 | 230 |
| 240 | 33.44 | 1.2291 | 0.05976 | 1033.2 | 2604.0 | 1037.3 | 1766.5 | 2803.8 | 2.7015 | 6.1437 | 240 |
| 250 | 39.73 | 1.2512 | 0.05013 | 1080.4 | 2602.4 | 1085.4 | 1716.2 | 2801.5 | 2.7927 | 6.0730 | 250 |
| 260 | 46.88 | 1.2755 | 0.04221 | 1128.4 | 2599.0 | 1134.4 | 1662.5 | 2796.6 | 2.8838 | 6.0019 | 260 |
| 270 | 54.99 | 1.3023 | 0.03564 | 1177.4 | 2593.7 | 1184.5 | 1605.2 | 2789.7 | 2.9751 | 5.9301 | 270 |
| 280 | 64.12 | 1.3321 | 0.03017 | 1227.5 | 2586.1 | 1236.0 | 1543.6 | 2779.6 | 3.0668 | 5.8571 | 280 |
| 290 | 74.36 | 1.3656 | 0.02557 | 1278.9 | 2576.0 | 1289.1 | 1477.1 | 2766.2 | 3.1594 | 5.7821 | 290 |
| 300 | 85.81 | 1.4038 | 0.02167 | 1332.0 | 2563.0 | 1344.0 | 1404.9 | 2749.0 | 3.2534 | 5.7045 | 300 |
| 320 | 112.7 | 1.4988 | 0.01549 | 1444.6 | 2525.5 | 1461.5 | 1238.6 | 2700.1 | 3.4480 | 5.5362 | 320 |
| 340 | 145.9 | 1.6379 | 0.01090 | 1570.3 | 2464.8 | 1594.2 | 1027.9 | 2622.0 | 3.6594 | 5.3357 | 340 |
| 360 | 186.5 | 1.8925 | 0.006945 | 1725.2 | 2351.5 | 1760.5 | 720.5 | 2481.0 | 3.9147 | 5.0526 | 360 |
| 374.14 | 220.9 | 3.155 | 0.003155 | 2029.6 | 2029.6 | 2099.3 | 0 | 2099.3 | 4.4298 | 4.4298 | 374.14 |

Properties of Saturated Water (Liquid-Vapor): Pressure Table

Pressure Conversions:
1 bar = 0.1 MPa
= 10⁵ kPa

| Press. bar | Temp. °C | Specific Volume m ³ /kg | | Internal Energy kJ/kg | | Enthalpy kJ/kg | | | Entropy kJ/kg · K | | Press. bar |
|------------|----------|--|---------------------------|----------------------------|---------------------------|----------------------------|-----------------------|---------------------------|----------------------------|---------------------------|------------|
| | | Sat. Liquid u _f × 10 ³ | Sat. Vapor u _g | Sat. Liquid u _f | Sat. Vapor u _g | Sat. Liquid h _f | Evap. h _{fg} | Sat. Vapor h _g | Sat. Liquid s _f | Sat. Vapor s _g | |
| 0.04 | 28.98 | 1.0040 | 34.800 | 121.45 | 2415.2 | 121.46 | 2432.9 | 2554.4 | 0.4226 | 8.4746 | 0.04 |
| 0.06 | 36.16 | 1.0064 | 23.739 | 151.53 | 2425.0 | 151.53 | 2415.9 | 2567.4 | 0.5210 | 8.3304 | 0.06 |
| 0.08 | 41.51 | 1.0084 | 18.103 | 173.87 | 2432.2 | 173.88 | 2403.1 | 2577.0 | 0.5926 | 8.2287 | 0.08 |
| 0.10 | 45.81 | 1.0102 | 14.574 | 191.82 | 2437.9 | 191.83 | 2392.8 | 2584.7 | 0.6493 | 8.1502 | 0.10 |
| 0.20 | 60.06 | 1.0172 | 7.649 | 251.38 | 2456.7 | 251.40 | 2358.3 | 2609.7 | 0.8320 | 7.9085 | 0.20 |
| 0.30 | 69.10 | 1.0223 | 5.229 | 289.20 | 2468.4 | 289.23 | 2336.1 | 2625.3 | 0.9439 | 7.7686 | 0.30 |
| 0.40 | 75.87 | 1.0265 | 3.993 | 317.53 | 2477.0 | 317.58 | 2319.2 | 2636.8 | 1.0259 | 7.6700 | 0.40 |
| 0.50 | 81.33 | 1.0300 | 3.240 | 340.44 | 2483.9 | 340.49 | 2305.4 | 2645.9 | 1.0910 | 7.5939 | 0.50 |
| 0.60 | 85.94 | 1.0331 | 2.732 | 359.79 | 2489.6 | 359.86 | 2293.6 | 2653.5 | 1.1453 | 7.5320 | 0.60 |
| 0.70 | 89.95 | 1.0360 | 2.365 | 376.63 | 2494.5 | 376.70 | 2283.3 | 2660.0 | 1.1919 | 7.4797 | 0.70 |
| 0.80 | 93.50 | 1.0389 | 2.087 | 391.58 | 2498.8 | 391.68 | 2274.1 | 2665.8 | 1.2329 | 7.4346 | 0.80 |
| 0.90 | 96.71 | 1.0410 | 1.869 | 405.06 | 2502.6 | 405.15 | 2265.7 | 2670.9 | 1.2695 | 7.3949 | 0.90 |
| 1.00 | 99.63 | 1.0432 | 1.694 | 417.36 | 2506.1 | 417.46 | 2258.0 | 2675.5 | 1.3026 | 7.3594 | 1.00 |
| 1.50 | 111.4 | 1.0528 | 1.159 | 468.94 | 2519.7 | 467.11 | 2226.5 | 2693.6 | 1.4396 | 7.2233 | 1.50 |
| 2.00 | 120.2 | 1.0605 | 0.8857 | 504.49 | 2529.5 | 504.70 | 2201.9 | 2706.7 | 1.5301 | 7.1271 | 2.00 |
| 2.50 | 127.4 | 1.0672 | 0.7187 | 535.10 | | | | | | | |

Properties of Superheated Water Vapor

(Continued)

Table with 4 columns of data for pressures p = 0.06 bar, 0.35 bar, 5.0 bar, and 7.0 bar. Each column lists temperature (T) and properties (v, u, h, s) at various temperatures.

Table for p = 0.70 bar = 0.07 MPa (Tsat = 89.95°C). Lists T, v, u, h, s for temperatures from 100 to 500.

Table for p = 1.0 bar = 0.10 MPa (Tsat = 99.63°C). Lists T, v, u, h, s for temperatures from 120 to 500.

Table for p = 10.0 bar = 1.0 MPa (Tsat = 179.91°C). Lists T, v, u, h, s for temperatures from 200 to 600.

Table for p = 15.0 bar = 1.5 MPa (Tsat = 198.32°C). Lists T, v, u, h, s for temperatures from 200 to 600.

Table for p = 1.5 bar = 0.15 MPa (Tsat = 111.37°C). Lists T, v, u, h, s for temperatures from 120 to 600.

Table for p = 3.0 bar = 0.30 MPa (Tsat = 133.55°C). Lists T, v, u, h, s for temperatures from 120 to 600.

Table for p = 20.0 bar = 2.0 MPa (Tsat = 212.42°C). Lists T, v, u, h, s for temperatures from 240 to 700.

Table for p = 30.0 bar = 3.0 MPa (Tsat = 233.90°C). Lists T, v, u, h, s for temperatures from 240 to 700.

(Continued)

(Continued)

Table for p = 40 bar = 4.0 MPa (Tsat = 250.4°C). Lists T, v, u, h, s for temperatures from 280 to 740.

Table for p = 60 bar = 6.0 MPa (Tsat = 275.64°C). Lists T, v, u, h, s for temperatures from 280 to 740.

Table for p = 160 bar = 16.0 MPa (Tsat = 347.44°C). Lists T, v, u, h, s for temperatures from 360 to 740.

Table for p = 180 bar = 18.0 MPa (Tsat = 357.06°C). Lists T, v, u, h, s for temperatures from 360 to 740.

Table for p = 80 bar = 8.0 MPa (Tsat = 295.06°C). Lists T, v, u, h, s for temperatures from 320 to 740.

Table for p = 100 bar = 10.0 MPa (Tsat = 311.06°C). Lists T, v, u, h, s for temperatures from 320 to 740.

Table for p = 200 bar = 20.0 MPa (Tsat = 365.81°C). Lists T, v, u, h, s for temperatures from 360 to 800.

Table for p = 240 bar = 24.0 MPa. Lists T, v, u, h, s for temperatures from 360 to 800.

Table for p = 120 bar = 12.0 MPa (Tsat = 324.75°C). Lists T, v, u, h, s for temperatures from 360 to 740.

Table for p = 140 bar = 14.0 MPa (Tsat = 336.75°C). Lists T, v, u, h, s for temperatures from 360 to 740.

Table for p = 280 bar = 28.0 MPa. Lists T, v, u, h, s for temperatures from 360 to 800.

Table for p = 320 bar = 32.0 MPa. Lists T, v, u, h, s for temperatures from 360 to 800.

見背面

Ideal Gas Properties of Air

| T(K), h and u(kJ/kg), s° (kJ/kg · K) | | | | | | | | | | | | | |
|--------------------------------------|--------|--------|---------|----------------|----------------|-----|--------|--------|---------|----------------|----------------|-------------|--|
| | | | | when Δs = 0' | | | | | | | | when Δs = 0 | |
| T | h | u | s° | p _r | v _r | T | h | u | s° | p _r | v _r | | |
| 200 | 199.97 | 142.56 | 1.29559 | 0.3363 | 1707. | 450 | 451.80 | 322.62 | 2.11161 | 5.775 | 223.6 | | |
| 210 | 209.97 | 149.69 | 1.34444 | 0.3987 | 1512. | 460 | 462.02 | 329.97 | 2.13407 | 6.245 | 211.4 | | |
| 220 | 219.97 | 156.82 | 1.39105 | 0.4690 | 1346. | 470 | 472.24 | 337.32 | 2.15604 | 6.742 | 200.1 | | |
| 230 | 230.02 | 164.00 | 1.43557 | 0.5477 | 1205. | 480 | 482.49 | 344.70 | 2.17760 | 7.268 | 189.5 | | |
| 240 | 240.02 | 171.13 | 1.47824 | 0.6355 | 1084. | 490 | 492.74 | 352.08 | 2.19876 | 7.824 | 179.7 | | |
| 250 | 250.05 | 178.28 | 1.51917 | 0.7329 | 979. | 500 | 503.02 | 359.49 | 2.21952 | 8.411 | 170.6 | | |
| 260 | 260.09 | 185.45 | 1.55848 | 0.8405 | 887.8 | 510 | 513.32 | 366.92 | 2.23993 | 9.031 | 162.1 | | |
| 270 | 270.11 | 192.60 | 1.59634 | 0.9590 | 808.0 | 520 | 523.63 | 374.36 | 2.25997 | 9.684 | 154.1 | | |
| 280 | 280.13 | 199.75 | 1.63279 | 1.0889 | 738.0 | 530 | 533.98 | 381.84 | 2.27967 | 10.37 | 146.7 | | |
| 285 | 285.14 | 203.33 | 1.65055 | 1.1584 | 706.1 | 540 | 544.35 | 389.34 | 2.29906 | 11.10 | 139.7 | | |
| 290 | 290.16 | 206.91 | 1.66802 | 1.2311 | 676.1 | 550 | 554.74 | 396.86 | 2.31809 | 11.86 | 133.1 | | |
| 295 | 295.17 | 210.49 | 1.68515 | 1.3068 | 647.9 | 560 | 565.17 | 404.42 | 2.33685 | 12.66 | 127.0 | | |
| 300 | 300.19 | 214.07 | 1.70203 | 1.3860 | 621.2 | 570 | 575.59 | 411.97 | 2.35531 | 13.50 | 121.2 | | |
| 305 | 305.22 | 217.67 | 1.71865 | 1.4686 | 596.0 | 580 | 586.04 | 419.55 | 2.37348 | 14.38 | 115.7 | | |
| 310 | 310.24 | 221.25 | 1.73498 | 1.5546 | 572.3 | 590 | 596.52 | 427.15 | 2.39140 | 15.31 | 110.6 | | |
| 315 | 315.27 | 224.85 | 1.75106 | 1.6442 | 549.8 | 600 | 607.02 | 434.78 | 2.40902 | 16.28 | 105.8 | | |
| 320 | 320.29 | 228.42 | 1.76690 | 1.7375 | 528.6 | 610 | 617.53 | 442.42 | 2.42644 | 17.30 | 101.2 | | |
| 325 | 325.31 | 232.02 | 1.78249 | 1.8345 | 508.4 | 620 | 628.07 | 450.09 | 2.44356 | 18.36 | 96.92 | | |
| 330 | 330.34 | 235.61 | 1.79783 | 1.9352 | 489.4 | 630 | 638.63 | 457.78 | 2.46048 | 19.46 | 92.84 | | |
| 340 | 340.42 | 242.82 | 1.82790 | 2.149 | 454.1 | 640 | 649.22 | 465.50 | 2.47716 | 20.64 | 88.99 | | |
| 350 | 350.49 | 250.02 | 1.85708 | 2.379 | 422.2 | 650 | 659.84 | 473.25 | 2.49364 | 21.86 | 85.34 | | |
| 360 | 360.58 | 257.24 | 1.88543 | 2.626 | 393.4 | 660 | 670.47 | 481.01 | 2.50985 | 23.13 | 81.89 | | |
| 370 | 370.67 | 264.46 | 1.91313 | 2.892 | 367.2 | 670 | 681.14 | 488.81 | 2.52589 | 24.46 | 78.61 | | |
| 380 | 380.77 | 271.69 | 1.94001 | 3.176 | 343.4 | 680 | 691.82 | 496.62 | 2.54175 | 25.85 | 75.50 | | |
| 390 | 390.88 | 278.93 | 1.96633 | 3.481 | 321.5 | 690 | 702.52 | 504.45 | 2.55731 | 27.29 | 72.56 | | |
| 400 | 400.98 | 286.16 | 1.99194 | 3.806 | 301.6 | 700 | 713.27 | 512.33 | 2.57277 | 28.80 | 69.76 | | |
| 410 | 411.12 | 293.43 | 2.01699 | 4.153 | 283.3 | 710 | 724.04 | 520.23 | 2.58810 | 30.38 | 67.07 | | |
| 420 | 421.26 | 300.69 | 2.04142 | 4.522 | 266.6 | 720 | 734.82 | 528.14 | 2.60319 | 32.02 | 64.53 | | |
| 430 | 431.43 | 307.99 | 2.06533 | 4.915 | 251.1 | 730 | 745.62 | 536.07 | 2.61803 | 33.72 | 62.13 | | |
| 440 | 441.61 | 315.30 | 2.08870 | 5.332 | 236.8 | 740 | 756.44 | 544.02 | 2.63280 | 35.50 | 59.82 | | |

(Continued)

| T(K), h and u(kJ/kg), s° (kJ/kg · K) | | | | | | | | | | | | | |
|--------------------------------------|---------|---------|---------|----------------|----------------|------|---------|---------|---------|----------------|----------------|-------------|--|
| | | | | when Δs = 0' | | | | | | | | when Δs = 0 | |
| T | h | u | s° | p _r | v _r | T | h | u | s° | p _r | v _r | | |
| 750 | 767.29 | 551.99 | 2.64737 | 37.35 | 57.63 | 1300 | 1395.97 | 1022.82 | 3.27345 | 330.9 | 11.275 | | |
| 760 | 778.18 | 560.01 | 2.66176 | 39.27 | 55.54 | 1320 | 1419.76 | 1040.88 | 3.29160 | 352.5 | 10.747 | | |
| 770 | 789.11 | 568.07 | 2.67595 | 41.31 | 53.39 | 1340 | 1443.60 | 1058.94 | 3.30959 | 375.3 | 10.247 | | |
| 780 | 800.03 | 576.12 | 2.69013 | 43.35 | 51.64 | 1360 | 1467.49 | 1077.10 | 3.32724 | 399.1 | 9.780 | | |
| 790 | 810.99 | 584.21 | 2.70400 | 45.55 | 49.86 | 1380 | 1491.44 | 1095.26 | 3.34474 | 424.2 | 9.337 | | |
| 800 | 821.95 | 592.30 | 2.71787 | 47.75 | 48.08 | 1400 | 1515.42 | 1113.52 | 3.36200 | 450.5 | 8.919 | | |
| 820 | 843.98 | 608.59 | 2.74504 | 52.59 | 44.84 | 1420 | 1539.44 | 1131.77 | 3.37901 | 478.0 | 8.526 | | |
| 840 | 866.08 | 624.95 | 2.77170 | 57.60 | 41.85 | 1440 | 1563.51 | 1150.13 | 3.39586 | 506.9 | 8.153 | | |
| 860 | 888.27 | 641.40 | 2.79783 | 63.09 | 39.12 | 1460 | 1587.63 | 1168.49 | 3.41247 | 537.1 | 7.801 | | |
| 880 | 910.56 | 657.95 | 2.82344 | 68.98 | 36.61 | 1480 | 1611.79 | 1186.95 | 3.42892 | 568.8 | 7.468 | | |
| 900 | 932.93 | 674.58 | 2.84856 | 75.29 | 34.31 | 1500 | 1635.97 | 1205.41 | 3.44516 | 601.9 | 7.152 | | |
| 920 | 955.38 | 691.28 | 2.87324 | 82.05 | 32.18 | 1520 | 1660.23 | 1223.87 | 3.46120 | 636.5 | 6.854 | | |
| 940 | 977.92 | 708.08 | 2.89748 | 89.28 | 30.22 | 1540 | 1684.51 | 1242.43 | 3.47712 | 672.8 | 6.569 | | |
| 960 | 1000.55 | 725.02 | 2.92128 | 97.00 | 28.40 | 1560 | 1708.82 | 1260.99 | 3.49276 | 710.5 | 6.301 | | |
| 980 | 1023.25 | 741.98 | 2.94468 | 105.2 | 26.73 | 1580 | 1733.17 | 1279.65 | 3.50829 | 750.0 | 6.046 | | |
| 1000 | 1046.04 | 758.94 | 2.96770 | 114.0 | 25.17 | 1600 | 1757.57 | 1298.30 | 3.52364 | 791.2 | 5.804 | | |
| 1020 | 1068.89 | 776.10 | 2.99034 | 123.4 | 23.72 | 1620 | 1782.00 | 1316.96 | 3.53879 | 834.1 | 5.574 | | |
| 1040 | 1091.85 | 793.36 | 3.01260 | 133.3 | 22.39 | 1640 | 1806.46 | 1335.72 | 3.55381 | 878.9 | 5.355 | | |
| 1060 | 1114.86 | 810.62 | 3.03449 | 143.9 | 21.14 | 1660 | 1830.96 | 1354.48 | 3.56867 | 925.6 | 5.147 | | |
| 1080 | 1137.89 | 827.88 | 3.05608 | 155.2 | 19.98 | 1680 | 1855.50 | 1373.24 | 3.58335 | 974.2 | 4.949 | | |
| 1100 | 1161.07 | 845.33 | 3.07732 | 167.1 | 18.896 | 1700 | 1880.1 | 1392.7 | 3.5979 | 1025 | 4.761 | | |
| 1120 | 1184.28 | 862.79 | 3.09825 | 179.7 | 17.886 | 1750 | 1941.6 | 1439.8 | 3.6336 | 1161 | 4.328 | | |
| 1140 | 1207.57 | 880.35 | 3.11893 | 193.1 | 16.946 | 1800 | 2003.3 | 1487.2 | 3.6684 | 1310 | 3.944 | | |
| 1160 | 1230.92 | 897.91 | 3.13916 | 207.2 | 16.064 | 1850 | 2065.3 | 1534.9 | 3.7023 | 1475 | 3.601 | | |
| 1180 | 1254.34 | 915.57 | 3.15916 | 222.2 | 15.241 | 1900 | 2127.4 | 1582.6 | 3.7354 | 1655 | 3.295 | | |
| 1200 | 1277.79 | 933.33 | 3.17888 | 238.0 | 14.470 | 1950 | 2189.7 | 1630.6 | 3.7677 | 1852 | 3.022 | | |
| 1220 | 1301.31 | 951.09 | 3.19834 | 254.7 | 13.747 | 2000 | 2252.1 | 1678.7 | 3.7994 | 2068 | 2.776 | | |
| 1240 | 1324.93 | 968.95 | 3.21751 | 272.3 | 13.069 | 2050 | 2314.6 | 1726.8 | 3.8303 | 2303 | 2.555 | | |
| 1260 | 1348.55 | 986.90 | 3.23638 | 290.8 | 12.435 | 2100 | 2377.4 | 1775.3 | 3.8605 | 2559 | 2.356 | | |
| 1280 | 1372.24 | 1004.76 | 3.25510 | 310.4 | 11.835 | 2150 | 2440.3 | 1823.8 | 3.8901 | 2837 | 2.175 | | |
| | | | | | | 2200 | 2503.2 | 1872.4 | 3.9191 | 3138 | 2.012 | | |
| | | | | | | 2250 | 2566.4 | 1921.3 | 3.9474 | 3464 | 1.864 | | |

接次頁

題號： 251

國立臺灣大學 109 學年度碩士班招生考試試題

科目： 熱工學

題號： 251

節次： 8

共 5 頁之第 5 頁

Ideal Gas Properties of Selected Gases

Enthalpy $\bar{h}(T)$ and internal energy $\bar{u}(T)$, in kJ/kmol. Absolute entropy at 1 atm $\bar{s}^*(T)$, in kJ/kmol · K.

| T(K) | Carbon Dioxide, CO ₂ ($\bar{h}_f^\circ = -393,520$ kJ/kmol) | | | Carbon Monoxide, CO ($\bar{h}_f^\circ = -110,530$ kJ/kmol) | | | Water Vapor, H ₂ O ($\bar{h}_f^\circ = -241,820$ kJ/kmol) | | | Oxygen, O ₂ ($\bar{h}_f^\circ = 0$ kJ/kmol) | | | Nitrogen, N ₂ ($\bar{h}_f^\circ = 0$ kJ/kmol) | | | T(K) |
|------|--|-----------|-------------|--|-----------|-------------|--|-----------|-------------|--|-----------|-------------|--|-----------|-------------|------|
| | \bar{h} | \bar{u} | \bar{s}^* | \bar{h} | \bar{u} | \bar{s}^* | \bar{h} | \bar{u} | \bar{s}^* | \bar{h} | \bar{u} | \bar{s}^* | \bar{h} | \bar{u} | \bar{s}^* | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 220 | 6,601 | 4,772 | 202.966 | 6,391 | 4,562 | 188.683 | 7,295 | 5,466 | 178.576 | 6,404 | 4,575 | 196.171 | 6,391 | 4,562 | 182.638 | 220 |
| 230 | 6,938 | 5,026 | 204.464 | 6,683 | 4,771 | 189.980 | 7,628 | 5,715 | 180.054 | 6,694 | 4,782 | 197.461 | 6,683 | 4,770 | 183.938 | 230 |
| 240 | 7,280 | 5,285 | 205.920 | 6,975 | 4,979 | 191.221 | 7,961 | 5,965 | 181.471 | 6,984 | 4,989 | 198.696 | 6,975 | 4,979 | 185.180 | 240 |
| 250 | 7,627 | 5,548 | 207.337 | 7,266 | 5,188 | 192.411 | 8,294 | 6,215 | 182.831 | 7,275 | 5,197 | 199.885 | 7,266 | 5,188 | 186.370 | 250 |
| 260 | 7,979 | 5,817 | 208.717 | 7,558 | 5,396 | 193.554 | 8,627 | 6,466 | 184.139 | 7,566 | 5,405 | 201.027 | 7,558 | 5,396 | 187.514 | 260 |
| 270 | 8,335 | 6,091 | 210.062 | 7,849 | 5,604 | 194.654 | 8,961 | 6,716 | 185.399 | 7,858 | 5,613 | 202.128 | 7,849 | 5,604 | 188.614 | 270 |
| 280 | 8,697 | 6,369 | 211.376 | 8,140 | 5,812 | 195.173 | 9,296 | 6,968 | 186.616 | 8,150 | 5,822 | 203.191 | 8,141 | 5,813 | 189.673 | 280 |
| 290 | 9,063 | 6,651 | 212.660 | 8,432 | 6,020 | 196.735 | 9,631 | 7,219 | 187.791 | 8,443 | 6,032 | 204.218 | 8,432 | 6,021 | 190.695 | 290 |
| 298 | 9,364 | 6,885 | 213.685 | 8,669 | 6,190 | 197.543 | 9,904 | 7,425 | 188.720 | 8,682 | 6,203 | 205.033 | 8,669 | 6,190 | 191.502 | 298 |
| 300 | 9,431 | 6,939 | 213.915 | 8,723 | 6,229 | 197.723 | 9,966 | 7,472 | 188.928 | 8,736 | 6,242 | 205.213 | 8,723 | 6,229 | 191.682 | 300 |
| 310 | 9,807 | 7,230 | 215.146 | 9,014 | 6,437 | 198.678 | 10,302 | 7,725 | 190.030 | 9,030 | 6,453 | 206.177 | 9,014 | 6,437 | 192.638 | 310 |
| 320 | 10,186 | 7,526 | 216.351 | 9,306 | 6,645 | 199.603 | 10,639 | 7,978 | 191.098 | 9,325 | 6,664 | 207.112 | 9,306 | 6,645 | 193.562 | 320 |
| 330 | 10,570 | 7,826 | 217.534 | 9,597 | 6,854 | 200.500 | 10,976 | 8,232 | 192.136 | 9,620 | 6,877 | 208.020 | 9,597 | 6,853 | 194.459 | 330 |
| 340 | 10,959 | 8,131 | 218.694 | 9,889 | 7,062 | 201.371 | 11,314 | 8,487 | 193.144 | 9,916 | 7,090 | 208.904 | 9,888 | 7,061 | 195.328 | 340 |
| 350 | 11,351 | 8,439 | 219.831 | 10,181 | 7,271 | 202.217 | 11,652 | 8,742 | 194.125 | 10,213 | 7,303 | 209.765 | 10,180 | 7,270 | 196.173 | 350 |
| 360 | 11,748 | 8,752 | 220.948 | 10,473 | 7,480 | 203.040 | 11,992 | 8,998 | 195.081 | 10,511 | 7,518 | 210.604 | 10,471 | 7,478 | 196.995 | 360 |
| 370 | 12,148 | 9,068 | 222.044 | 10,765 | 7,689 | 203.842 | 12,331 | 9,255 | 196.012 | 10,809 | 7,733 | 211.423 | 10,763 | 7,687 | 197.794 | 370 |
| 380 | 12,552 | 9,392 | 223.122 | 11,058 | 7,899 | 204.622 | 12,672 | 9,513 | 196.920 | 11,109 | 7,949 | 212.222 | 11,055 | 7,895 | 198.572 | 380 |
| 390 | 12,960 | 9,718 | 224.182 | 11,351 | 8,108 | 205.383 | 13,014 | 9,771 | 197.807 | 11,409 | 8,166 | 213.002 | 11,347 | 8,104 | 199.331 | 390 |
| 400 | 13,372 | 10,046 | 225.225 | 11,644 | 8,319 | 206.125 | 13,356 | 10,030 | 198.673 | 11,711 | 8,384 | 213.765 | 11,640 | 8,314 | 200.071 | 400 |
| 410 | 13,787 | 10,378 | 226.250 | 11,938 | 8,529 | 206.850 | 13,699 | 10,290 | 199.521 | 12,012 | 8,603 | 214.510 | 11,932 | 8,523 | 200.794 | 410 |
| 420 | 14,206 | 10,714 | 227.258 | 12,232 | 8,740 | 207.549 | 14,043 | 10,551 | 200.350 | 12,314 | 8,822 | 215.241 | 12,225 | 8,733 | 201.499 | 420 |
| 430 | 14,628 | 11,053 | 228.252 | 12,526 | 8,951 | 208.252 | 14,388 | 10,813 | 201.160 | 12,618 | 9,043 | 215.955 | 12,518 | 8,943 | 202.189 | 430 |
| 440 | 15,054 | 11,393 | 229.230 | 12,821 | 9,163 | 208.929 | 14,734 | 11,075 | 201.955 | 12,923 | 9,264 | 216.656 | 12,811 | 9,153 | 202.863 | 440 |
| 450 | 15,483 | 11,742 | 230.194 | 13,116 | 9,375 | 209.593 | 15,080 | 11,339 | 202.734 | 13,228 | 9,487 | 217.342 | 13,105 | 9,363 | 203.523 | 450 |
| 460 | 15,916 | 12,091 | 231.144 | 13,412 | 9,587 | 210.243 | 15,428 | 11,603 | 203.497 | 13,535 | 9,710 | 218.016 | 13,399 | 9,574 | 204.170 | 460 |
| 470 | 16,351 | 12,444 | 232.080 | 13,708 | 9,800 | 210.880 | 15,777 | 11,869 | 204.247 | 13,842 | 9,935 | 218.676 | 13,693 | 9,786 | 204.803 | 470 |
| 480 | 16,791 | 12,800 | 233.004 | 14,005 | 10,014 | 211.504 | 16,126 | 12,135 | 204.982 | 14,151 | 10,160 | 219.326 | 13,988 | 9,997 | 205.424 | 480 |
| 490 | 17,232 | 13,158 | 233.916 | 14,302 | 10,228 | 212.117 | 16,477 | 12,403 | 205.705 | 14,460 | 10,386 | 219.963 | 14,285 | 10,210 | 206.033 | 490 |
| 500 | 17,678 | 13,521 | 234.814 | 14,600 | 10,443 | 212.719 | 16,828 | 12,671 | 206.413 | 14,770 | 10,614 | 220.589 | 14,581 | 10,423 | 206.630 | 500 |
| 510 | 18,126 | 13,885 | 235.700 | 14,898 | 10,658 | 213.310 | 17,181 | 12,940 | 207.112 | 15,082 | 10,842 | 221.206 | 14,876 | 10,635 | 207.216 | 510 |
| 520 | 18,576 | 14,253 | 236.575 | 15,197 | 10,874 | 213.890 | 17,534 | 13,211 | 207.799 | 15,395 | 11,071 | 221.812 | 15,172 | 10,848 | 207.792 | 520 |
| 530 | 19,029 | 14,622 | 237.439 | 15,497 | 11,090 | 214.460 | 17,889 | 13,482 | 208.475 | 15,708 | 11,301 | 222.409 | 15,469 | 11,062 | 208.358 | 530 |
| 540 | 19,485 | 14,996 | 238.292 | 15,797 | 11,307 | 215.020 | 18,245 | 13,755 | 209.139 | 16,022 | 11,533 | 222.997 | 15,766 | 11,277 | 208.914 | 540 |
| 550 | 19,945 | 15,372 | 239.135 | 16,097 | 11,524 | 215.572 | 18,601 | 14,028 | 209.795 | 16,338 | 11,765 | 223.576 | 16,064 | 11,492 | 209.461 | 550 |
| 560 | 20,407 | 15,751 | 239.962 | 16,399 | 11,743 | 216.115 | 18,959 | 14,303 | 210.440 | 16,654 | 11,998 | 224.146 | 16,363 | 11,707 | 209.999 | 560 |
| 570 | 20,870 | 16,131 | 240.789 | 16,701 | 11,961 | 216.649 | 19,318 | 14,579 | 211.075 | 16,971 | 12,232 | 224.708 | 16,662 | 11,923 | 210.528 | 570 |
| 580 | 21,337 | 16,515 | 241.602 | 17,003 | 12,181 | 217.175 | 19,678 | 14,856 | 211.702 | 17,290 | 12,467 | 225.262 | 16,962 | 12,139 | 211.049 | 580 |
| 590 | 21,807 | 16,902 | 242.405 | 17,307 | 12,401 | 217.693 | 20,039 | 15,134 | 212.320 | 17,609 | 12,703 | 225.808 | 17,262 | 12,356 | 211.562 | 590 |

試題隨卷繳回