# 國立中央大學 110 學年度碩士班考試入學試題

所別： 化學工程與材料工程學系 碩士班 甲組(一般生)　　　　共4頁　第1頁

科目： 輸送現象與單元操作

本科考試可使用計算器，廠牌、功能不拘　　　　＊請在答案卷(卡)內作答

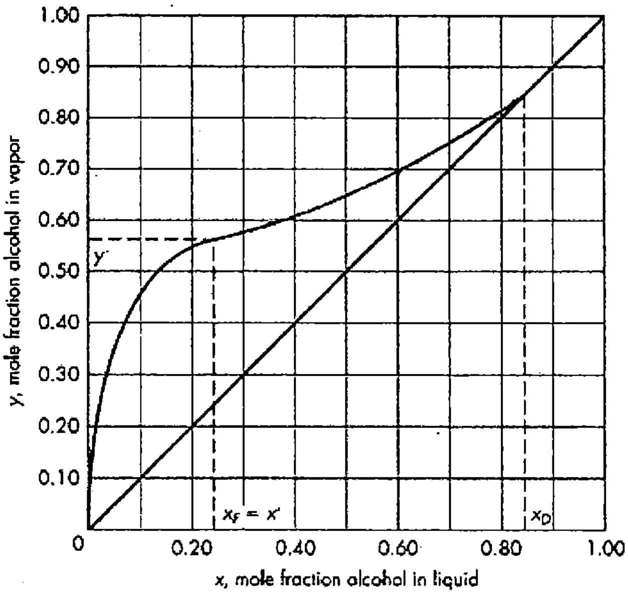
※計算題需計算過程，無計算過程者不予計分

1. (20 %) Please explain each of the terms in the following **(2 pts each)**.
   (a) Reynold number, (b) molecular momentum flux, (c) Prandtl mixing length, (d) velocity potential, (e) Reynolds stress, (f) form drag, (g) fanning friction factor, (h) eddy diffusivity, (i) divergence of velocity, (j) creeping flow.

2. (8%) Introduce the following dimensionless terms into the Navior-Stokes equation:
   $u^*=u/u_\infty$, dimensionless velocity
   $P^*=P/\rho\, u_\infty^2$, dimensionless pressure
   $t^*=t\, u_\infty/L$, dimensionless time
   $x^*=x/L$, dimensionless distance
   The operator $\nabla$ may then written $\nabla^*/L$. Show that the Navior-Stokes equation becomes
$$\frac{Du*}{Dt*}=\frac{gL}{u_\infty^2}-\nabla^*P^*+\frac{1}{Re}\nabla^{*2}u^*$$

3. (7 %) A packed bed is composed of cylinders having a diameter D=0.02 m and a length h=D. The bulk density of the overall packed bed is 962 $kg/m^3$ and the density of the solid cylinders is 1600 $kg/m^3$.
   (a) **(2 pts)** Calculate the void fraction $\varepsilon$.
   (b) **(3 pts)** Calculate the effective diameter $D_p$ of the particles.
   (c) **(2 pts)** Calculate the ratio of total surface area in the bed to total volume of bed in $m^{-1}$

4. (10%) Please recreate the diagram provided below in your answer sheet, and draw the “minimum reflux ratio” and “minimum operating ratio” operating lines. Clearly label the two lines.




注意:背面有試題

5. (25%) A pipeline transporting cold water is surrounded by stagnant air that is both hot and humid, and moisture continually diffuses to the cold surface of the pipe to form condensation. The condensed water forms a liquid film around the pipe, which drops off. At a distance of 10 cm from the exterior of the pipe, the relative humidity is constant, while close to the pipe the moisture content approaches the vapor pressure of water evaluated at the temperature of the pipe.

(a) Which coordinate system best describes this transfer process? List three major assumptions. (5 pts)

(b) Provide the simplified form of the general differential equation for mass transfer in terms of the flux of water vapor, $N_A$. (5 pts)

(c) What is the simplified form of Fick's flux equation for water vapor, $N_A$? (5 pts)

(d) Provide the simplified form of the general differential equation for mass transfer in terms of the concentration of water vapor, $C_A$? (10 pts)

6. (30%) A team of engineers for a defense contractor are commissioned by the naval force of a global power to build a nuclear submarine. The specs for the submarine, as demanded by the navy in order to designate the submarine as the Los Angeles Class, is as follows,

- Weight: 7,000 tones (1 tone = 1,000 kg)
- Top speed when submerged: 20 knots (~37 km/hr)
- Acceleration from rest to top speed when submerged: 1 minute

It is also estimated that all the friction experienced by a submarine submerged in sea water is $3.86 \times 10^6$ N. Moreover, such a submarine is conventionally propelled by a steam-driven turbine, with the high-pressure steam generated from a boiler heated by the nuclear reaction. Now, you are assigned the most critical part of the project – design the heat exchange system for the power generation system of the submarine – and need to determine the operation condition of the heat exchanger. Before that can be done, several other operation parameters have to be known in advance. (1) In the steady-state operation, steam leaving the turbine is condensed and recycled back to the boiler. For the sake of efficacy, steam from the outlet of the turbine is set to 1 bar and 100°C. Given the steam flow rate of 20 kg/s, determine the minimal temperature and pressure of steam entering the turbine (assuming entropy generation $\dot{S}_{gen} = 0$). **(4 pts)** (2) Given that compressed water of 100°C and 10 MPa is steadily supplied to the boiler, determine the operation temperature of the boiler and the heat generation rate which must be achieved by the nuclear reaction to maintain the steady and saturated state of steam at the pressure determined in (1). **(4 pts)** (3) A temperature discrepancy thus exists between steam leaving the boiler and the one entering the turbine. Making up the discrepancy stands the reason for deploying a heat exchanger in between the boiler and the turbine. Determine the overall heat transfer rate of the heat exchanger. **(4 pts)** (4) You decide to employ a counterflow, concentric tube heat exchanger for the purpose. Given the condition that the cooling fluid – water – is at 10°C and the diameters of the outer annulus and inner tube are to be 45 cm and 25 cm, respectively, determine the respective convection heat transfer coefficients for cooling water and steam. **(9 pts)** Explain the physical meanings of Reynolds and Nusselt numbers, which are relevant for addressing the question. **(2 pts)** (5) With the results of (4), determine the overall heat transfer coefficient and thereby the length of the heat exchanger to be built. **(7 pts)** (Important: Make every necessary assumption and give your reasoning. This will be taken into

所別： 化學工程與材料工程學系 碩士班 甲組(一般生) 共4頁 第3頁

科目： 輸送現象與單元操作

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consideration when your answers are graded.)

**Some useful information**

- $\vec{F} = m\vec{a}$; $W = \vec{F} \cdot \vec{s}$
- $Nu_D = 0.023Re_D^{4/5}Pr^n$; $Nu_D = 0.027Re_D^{4/5}Pr^{1/3}(\mu/\mu_s)^{0.14}$

Superheated Vapor (*Continued*)

| | P = 4.0 MPa (250.40) | | | | P = 4.5 MPa (257.49) | | | |
|---|---|---|---|---|---|---|---|---|
| T (°C) | $\hat{V}$ | $\hat{U}$ | $\hat{H}$ | $\hat{S}$ | $\hat{V}$ | $\hat{U}$ | $\hat{H}$ | $\hat{S}$ |
| Sat. | 0.049 78 | 2602.3 | 2801.4 | 6.0701 | 0.044 06 | 2600.1 | 2798.3 | 6.0198 |
| 275 | 0.054 57 | 2667.9 | 2886.2 | 6.2285 | 0.047 30 | 2650.3 | 2863.2 | 6.1401 |
| 300 | 0.058 84 | 2725.3 | 2960.7 | 6.3615 | 0.051 35 | 2712.0 | 2943.1 | 6.2828 |
| 350 | 0.066 45 | 2826.7 | 3092.5 | 6.5821 | 0.058 40 | 2817.8 | 3080.6 | 6.5131 |
| 400 | 0.073 41 | 2919.9 | 3213.6 | 6.7690 | 0.064 75 | 2913.3 | 3204.7 | 6.7047 |
| 450 | 0.080 02 | 3010.2 | 3330.3 | 6.9363 | 0.070 74 | 3005.0 | 3323.3 | 6.8746 |
| 500 | 0.086 43 | 3099.5 | 3445.3 | 7.0901 | 0.076 51 | 3095.3 | 3439.6 | 7.0301 |
| 600 | 0.098 85 | 3279.1 | 3674.4 | 7.3688 | 0.087 65 | 3276.0 | 3670.5 | 7.3110 |
| 700 | 0.110 95 | 3462.1 | 3905.9 | 7.6198 | 0.098 47 | 3459.9 | 3903.0 | 7.5631 |
| 800 | 0.122 87 | 3650.0 | 4141.5 | 7.8502 | 0.109 11 | 3648.3 | 4139.3 | 7.7942 |
| 900 | 0.134 69 | 3843.6 | 4382.3 | 8.0647 | 0.119 65 | 3842.2 | 4380.6 | 8.0091 |
| 1000 | 0.146 45 | 4042.9 | 4628.7 | 8.2662 | 0.130 13 | 4041.6 | 4627.2 | 8.2108 |
| 1100 | 0.158 17 | 4248.0 | 4880.6 | 8.4567 | 0.140 56 | 4246.8 | 4879.3 | 8.4015 |
| 1200 | 0.169 87 | 4458.6 | 5138.1 | 8.6376 | 0.150 98 | 4457.5 | 5136.9 | 8.5825 |
| 1300 | 0.181 56 | 4674.3 | 5400.5 | 8.8100 | 0.161 39 | 4673.1 | 5399.4 | 8.7549 |
| | P = 6.0 MPa (275.64) | | | | P = 7.0 MPa (285.88) | | | |
| Sat. | 0.032 44 | 2589.7 | 2784.3 | 5.8892 | 0.027 37 | 2580.5 | 2772.1 | 5.8133 |
| 300 | 0.036 16 | 2667.2 | 2884.2 | 6.0674 | 0.029 47 | 2632.2 | 2838.4 | 5.9305 |
| 350 | 0.042 23 | 2789.6 | 3043.0 | 6.3335 | 0.035 24 | 2769.4 | 3016.0 | 6.2283 |
| 400 | 0.047 39 | 2892.9 | 3177.2 | 6.5408 | 0.039 93 | 2878.6 | 3158.1 | 6.4478 |
| 450 | 0.052 14 | 2988.9 | 3301.8 | 6.7193 | 0.044 16 | 2978.0 | 3287.1 | 6.6327 |
| 500 | 0.056 65 | 3082.2 | 3422.2 | 6.8803 | 0.048 14 | 3073.4 | 3410.3 | 6.7975 |
| 550 | 0.061 01 | 3174.6 | 3540.6 | 7.0288 | 0.051 95 | 3167.2 | 3530.9 | 6.9486 |
| 600 | 0.065 25 | 3266.9 | 3658.4 | 7.1677 | 0.055 65 | 3260.7 | 3650.3 | 7.0894 |
| 700 | 0.073 52 | 3453.1 | 3894.2 | 7.4234 | 0.062 83 | 3448.5 | 3888.3 | 7.3476 |
| 800 | 0.081 60 | 3643.1 | 4132.7 | 7.6566 | 0.069 81 | 3639.5 | 4128.2 | 7.5822 |
| 900 | 0.089 58 | 3837.8 | 4375.3 | 7.8727 | 0.076 69 | 3835.0 | 4371.8 | 7.7991 |
| 1000 | 0.097 49 | 4037.8 | 4622.7 | 8.0751 | 0.083 50 | 4035.3 | 4619.8 | 8.0020 |
| 1100 | 0.105 36 | 4243.3 | 4875.4 | 8.2661 | 0.090 27 | 4240.9 | 4872.8 | 8.1933 |
| 1200 | 0.113 21 | 4454.0 | 5133.3 | 8.4474 | 0.097 03 | 4451.7 | 5130.9 | 8.3747 |
| 1300 | 0.121 06 | 4669.6 | 5396.0 | 8.6199 | 0.103 77 | 4667.3 | 5393.7 | 8.5473 |
| | P = 9.0 MPa (303.40) | | | | P = 10.0 MPa (311.06) | | | |
| Sat. | 0.020 48 | 2557.8 | 2742.1 | 5.6772 | 0.018 026 | 2544.4 | 2724.7 | 5.6141 |
| 325 | 0.023 27 | 2646.6 | 2856.0 | 5.8712 | 0.019 861 | 2610.4 | 2809.1 | 5.7568 |
| 350 | 0.025 80 | 2724.4 | 2956.6 | 6.0361 | 0.022 42 | 2699.2 | 2923.4 | 5.9443 |
| 400 | 0.029 93 | 2848.4 | 3117.8 | 6.2854 | 0.026 41 | 2832.4 | 3096.5 | 6.2120 |
| 450 | 0.033 50 | 2955.2 | 3256.6 | 6.4844 | 0.029 75 | 2943.4 | 3240.9 | 6.4190 |
| 500 | 0.036 77 | 3055.2 | 3386.1 | 6.6576 | 0.032 79 | 3045.8 | 3373.7 | 6.5966 |
| 550 | 0.039 87 | 3152.2 | 3511.0 | 6.8142 | 0.035 64 | 3144.6 | 3500.9 | 6.7561 |
| 600 | 0.042 85 | 3248.1 | 3633.7 | 6.9589 | 0.038 37 | 3241.7 | 3625.3 | 6.9029 |
| 650 | 0.045 74 | 3343.6 | 3755.3 | 7.0943 | 0.041 07 | 3338.2 | 3748.2 | 7.0398 |
| 700 | 0.048 57 | 3439.3 | 3876.5 | 7.2221 | 0.043 58 | 3434.7 | 3870.5 | 7.1687 |
| 800 | 0.054 09 | 3632.5 | 4119.3 | 7.4596 | 0.048 59 | 3628.9 | 4114.8 | 7.4077 |
| 900 | 0.059 50 | 3829.2 | 4364.8 | 7.6783 | 0.053 49 | 3826.3 | 4361.2 | 7.6272 |
| 1000 | 0.064 85 | 4030.3 | 4614.0 | 7.8821 | 0.058 32 | 4027.8 | 4611.0 | 7.8315 |
| 1100 | 0.070 16 | 4236.3 | 4867.7 | 8.0740 | 0.063 12 | 4234.0 | 4865.1 | 8.0237 |
| 1200 | 0.075 44 | 4447.2 | 5126.2 | 8.2556 | 0.067 89 | 4444.9 | 5123.8 | 8.2055 |
| 1300 | 0.080 72 | 4662.7 | 5389.2 | 8.4284 | 0.072 65 | 4460.5 | 5387.0 | 8.3783 |

$\hat{V}$ [=] m³/kg; $\hat{U}$, $\hat{H}$ [=] J/g = kJ/kg; $\hat{S}$ [=] kJ/kg K

Compressed Liquid

| | P = 5 MPa (263.99) | | | | P = 10 MPa (311.06) | | | |
|---|---|---|---|---|---|---|---|---|
| T (°C) | $\hat{V}$ | $\hat{U}$ | $\hat{H}$ | $\hat{S}$ | $\hat{V}$ | $\hat{U}$ | $\hat{H}$ | $\hat{S}$ |
| Sat. | 0.001 285 9 | 1147.8 | 1154.2 | 2.9202 | 0.001 452 4 | 1393.0 | 1407.6 | 3.3596 |
| 0 | 0.000 997 7 | 0.04 | 5.04 | 0.0001 | 0.000 995 2 | 0.09 | 10.04 | 0.0002 |
| 20 | 0.000 999 5 | 83.65 | 88.65 | 0.2956 | 0.000 997 2 | 83.36 | 93.33 | 0.2945 |
| 40 | 0.001 005 6 | 166.95 | 171.97 | 0.5705 | 0.001 003 4 | 166.35 | 176.38 | 0.5686 |
| 60 | 0.001 014 9 | 250.23 | 255.30 | 0.8285 | 0.001 012 7 | 249.36 | 259.49 | 0.8258 |
| 80 | 0.001 026 8 | 333.72 | 338.85 | 1.0720 | 0.001 024 5 | 332.59 | 342.83 | 1.0688 |
| 100 | 0.001 041 0 | 417.52 | 422.72 | 1.3030 | 0.001 038 5 | 416.12 | 426.50 | 1.2992 |
| 120 | 0.001 057 6 | 501.80 | 507.09 | 1.5233 | 0.001 054 9 | 500.08 | 510.64 | 1.5189 |
| 140 | 0.001 076 8 | 586.76 | 592.15 | 1.7343 | 0.001 073 7 | 584.68 | 595.42 | 1.7292 |
| 160 | 0.001 098 8 | 672.62 | 678.12 | 1.9375 | 0.001 095 3 | 670.13 | 681.08 | 1.9317 |
| 180 | 0.001 124 0 | 759.63 | 765.25 | 2.1341 | 0.001 119 9 | 756.65 | 767.84 | 2.1275 |
| 200 | 0.001 153 0 | 848.1 | 853.9 | 2.3255 | 0.001 148 0 | 844.5 | 856.0 | 2.3178 |
| 220 | 0.001 186 6 | 938.4 | 944.4 | 2.5128 | 0.001 180 5 | 934.1 | 945.9 | 2.5039 |
| 240 | 0.001 226 4 | 1031.4 | 1037.5 | 2.6979 | 0.001 218 7 | 1026.0 | 1038.1 | 2.6872 |
| 260 | 0.001 274 9 | 1127.9 | 1134.3 | 2.8830 | 0.001 264 5 | 1121.1 | 1133.7 | 2.8699 |
| 280 | | | | | 0.001 321 6 | 1220.9 | 1234.1 | 3.0548 |
| 300 | | | | | 0.001 397 2 | 1328.4 | 1342.3 | 3.2469 |
| 320 | | | | | | | | |
| 340 | | | | | | | | |
| | P = 20 MPa (365.81) | | | | P = 30 MPa | | | |
| Sat. | 0.002 036 | 1785.6 | 1826.3 | 4.0139 | | | | |
| 0 | 0.000 990 4 | 0.19 | 20.01 | 0.0004 | 0.000 985 6 | 0.25 | 29.82 | 0.0001 |
| 20 | 0.000 992 8 | 82.77 | 102.62 | 0.2923 | 0.000 988 6 | 82.17 | 111.84 | 0.2899 |
| 40 | 0.000 999 2 | 165.17 | 185.16 | 0.5646 | 0.000 995 1 | 164.04 | 193.89 | 0.5607 |
| 60 | 0.001 008 4 | 247.68 | 267.85 | 0.8206 | 0.001 004 2 | 246.06 | 276.19 | 0.8154 |
| 80 | 0.001 019 9 | 330.40 | 350.80 | 1.0624 | 0.001 015 6 | 328.30 | 358.77 | 1.0561 |
| 100 | 0.001 033 7 | 413.39 | 434.06 | 1.2917 | 0.001 029 0 | 410.78 | 441.66 | 1.2844 |
| 120 | 0.001 049 6 | 496.76 | 517.76 | 1.5102 | 0.001 044 5 | 493.59 | 524.93 | 1.5018 |
| 140 | 0.001 067 8 | 580.69 | 602.04 | 1.7193 | 0.001 062 1 | 576.88 | 608.75 | 1.7098 |
| 160 | 0.001 088 5 | 665.35 | 687.12 | 1.9204 | 0.001 082 1 | 660.82 | 693.28 | 1.9096 |
| 180 | 0.001 112 0 | 750.95 | 773.20 | 2.1147 | 0.001 104 7 | 745.59 | 778.73 | 2.1024 |
| 200 | 0.001 138 8 | 837.7 | 860.5 | 2.3031 | 0.001 130 2 | 831.4 | 865.3 | 2.2893 |
| 220 | 0.001 169 3 | 925.9 | 949.3 | 2.4870 | 0.001 159 0 | 918.3 | 953.1 | 2.4711 |
| 240 | 0.001 204 6 | 1016.0 | 1040.0 | 2.6674 | 0.001 192 0 | 1006.9 | 1042.6 | 2.6490 |
| 260 | 0.001 246 2 | 1108.6 | 1133.5 | 2.8459 | 0.001 230 3 | 1097.4 | 1134.3 | 2.8243 |
| 280 | 0.001 296 5 | 1204.7 | 1230.6 | 3.0248 | 0.001 275 5 | 1190.7 | 1229.0 | 2.9986 |
| 300 | 0.001 359 6 | 1306.1 | 1333.3 | 3.2071 | 0.001 330 4 | 1287.9 | 1327.8 | 3.1741 |
| 320 | 0.001 443 7 | 1415.7 | 1444.6 | 3.3979 | 0.001 399 7 | 1390.7 | 1432.7 | 3.3539 |
| 340 | 0.001 568 4 | 1539.7 | 1571.0 | 3.6075 | 0.001 492 0 | 1501.7 | 1546.5 | 3.5426 |
| 360 | 0.001 822 6 | 1702.8 | 1739.3 | 3.8772 | 0.001 626 5 | 1626.6 | 1675.4 | 3.7494 |
| 380 | | | | | 0.001 869 1 | 1781.4 | 1837.5 | 4.0012 |

$\hat{V}$ [=] m³/kg; $\hat{U}$, $\hat{H}$ [=] J/g = kJ/kg; $\hat{S}$ [=] kJ/kg K

注意:背面有試題

# 國立中央大學110學年度碩士班考試入學試題

所別： 化學工程與材料工程學系 碩士班 甲組(一般生) 共4頁 第4頁

科目： 輸送現象與單元操作

本科考試可使用計算器，廠牌、功能不拘 *請在答案卷(卡)內作答

TABLE A.6 Thermophysical Properties of Saturated Water[a]

| Temperature, $T$ (K) | Pressure, $p$ (bars)[b] | Specic Volume ($m^3/kg$) $v_f \cdot 10^3$ | $v_g$ | Heat of Vaporization, $h_{fg}$ (kJ/kg) | Specic Heat (kJ/kg · K) $c_{p,f}$ | $c_{p,g}$ | Viscosity ($N \cdot s/m^2$) $\mu_f \cdot 10^6$ | $\mu_g \cdot 10^6$ | Thermal Conductivity (W/m · K) $k_f \cdot 10^3$ | $k_g \cdot 10^3$ | Prandtl Number $Pr_f$ | $Pr_g$ | Surface Tension, $\sigma_f \cdot 10^3$ (N/m) | Expansion Coefficient, $\beta_f \cdot 10^6$ ($K^{-1}$) | Temperature, $T$ (K) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 370 | 0.9040 | 1.041 | 1.861 | 2265 | 4.214 | 2.017 | 289 | 11.89 | 679 | 24.5 | 1.80 | 0.978 | 59.5 | 728.7 | 370 |
| 373.15 | 1.0133 | 1.044 | 1.679 | 2257 | 4.217 | 2.029 | 279 | 12.02 | 680 | 24.8 | 1.76 | 0.984 | 58.9 | 750.1 | 373.15 |
| 375 | 1.0815 | 1.045 | 1.574 | 2252 | 4.220 | 2.036 | 274 | 12.09 | 681 | 24.9 | 1.70 | 0.987 | 58.6 | 761 | 375 |
| 380 | 1.2869 | 1.049 | 1.337 | 2239 | 4.226 | 2.057 | 260 | 12.29 | 683 | 25.4 | 1.61 | 0.999 | 57.6 | 788 | 380 |
| 385 | 1.5233 | 1.053 | 1.142 | 2225 | 4.232 | 2.080 | 248 | 12.49 | 685 | 25.8 | 1.53 | 1.004 | 56.6 | 814 | 385 |
| 390 | 1.794 | 1.058 | 0.980 | 2212 | 4.239 | 2.104 | 237 | 12.69 | 686 | 26.3 | 1.47 | 1.013 | 55.6 | 841 | 390 |
| 400 | 2.455 | 1.067 | 0.731 | 2183 | 4.256 | 2.158 | 217 | 13.05 | 688 | 27.2 | 1.34 | 1.033 | 53.6 | 896 | 400 |
| 410 | 3.302 | 1.077 | 0.553 | 2153 | 4.278 | 2.221 | 200 | 13.42 | 688 | 28.2 | 1.24 | 1.054 | 51.5 | 952 | 410 |
| 420 | 4.370 | 1.088 | 0.425 | 2123 | 4.302 | 2.291 | 185 | 13.79 | 688 | 29.8 | 1.16 | 1.075 | 49.4 | 1010 | 420 |
| 430 | 5.699 | 1.099 | 0.331 | 2091 | 4.331 | 2.369 | 173 | 14.14 | 685 | 30.4 | 1.09 | 1.10 | 47.2 | | 430 |
| 440 | 7.333 | 1.110 | 0.261 | 2059 | 4.36 | 2.46 | 162 | 14.50 | 682 | 31.7 | 1.04 | 1.12 | 45.1 | | 440 |
| 450 | 9.319 | 1.123 | 0.208 | 2024 | 4.40 | 2.56 | 152 | 14.85 | 678 | 33.1 | 0.99 | 1.14 | 42.9 | | 450 |
| 460 | 11.71 | 1.137 | 0.167 | 1989 | 4.44 | 2.68 | 143 | 15.19 | 673 | 34.6 | 0.95 | 1.17 | 40.7 | | 460 |
| 470 | 14.55 | 1.152 | 0.136 | 1951 | 4.48 | 2.79 | 136 | 15.54 | 667 | 36.3 | 0.92 | 1.20 | 38.5 | | 470 |
| 480 | 17.90 | 1.167 | 0.111 | 1912 | 4.53 | 2.94 | 129 | 15.88 | 660 | 38.1 | 0.89 | 1.23 | 36.2 | | 480 |
| 490 | 21.83 | 1.184 | 0.0922 | 1870 | 4.59 | 3.10 | 124 | 16.23 | 651 | 40.1 | 0.87 | 1.25 | 33.9 | — | 490 |
| 500 | 26.40 | 1.203 | 0.0766 | 1825 | 4.66 | 3.27 | 118 | 16.59 | 642 | 42.3 | 0.86 | 1.28 | 31.6 | — | 500 |
| 510 | 31.66 | 1.222 | 0.0631 | 1779 | 4.74 | 3.47 | 113 | 16.95 | 631 | 44.7 | 0.85 | 1.31 | 29.3 | — | 510 |
| 520 | 37.70 | 1.244 | 0.0525 | 1730 | 4.84 | 3.70 | 108 | 17.33 | 621 | 47.5 | 0.84 | 1.35 | 26.9 | — | 520 |
| 530 | 44.58 | 1.268 | 0.0445 | 1679 | 4.95 | 3.96 | 104 | 17.72 | 608 | 50.6 | 0.85 | 1.39 | 24.5 | — | 530 |

Saturated Steam: Pressure Table (*Continued*)

| Press. (kPa) | Temp (°C) | Specific Volume | | Internal Energy | | | Enthalpy | | | Entropy | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sat. Liquid | Sat. Vapor | Sat. Liquid | Evap. | Sat. Vapor | Sat. Liquid | Evap. | Sat. Vapor | Sat. Liquid | Evap. | Sat. Vapor |
| $P$ | $T$ | $\hat{V}^L$ | $\hat{V}^V$ | $\hat{U}^L$ | $\Delta\hat{U}$ | $\hat{U}^V$ | $\hat{H}^L$ | $\Delta\hat{H}$ | $\hat{H}^V$ | $\hat{S}^L$ | $\Delta\hat{S}$ | $\hat{S}^V$ |
| 1.00 | 179.91 | 0.001 127 | 0.194 44 | 761.68 | 1822.0 | 2583.6 | 762.81 | 2015.3 | 2778.1 | 2.1387 | 4.4478 | 6.5865 |
| 1.10 | 184.09 | 0.001 133 | 0.177 53 | 780.09 | 1806.3 | 2586.4 | 781.34 | 2000.4 | 2781.7 | 2.1792 | 4.3744 | 6.5536 |
| 1.20 | 187.99 | 0.001 139 | 0.163 33 | 797.29 | 1791.5 | 2588.8 | 798.65 | 1986.2 | 2784.8 | 2.2166 | 4.3067 | 6.5233 |
| 1.30 | 191.64 | 0.001 144 | 0.151 25 | 813.44 | 1777.5 | 2591.0 | 814.93 | 1972.7 | 2787.6 | 2.2515 | 4.2438 | 6.4953 |
| 1.40 | 195.07 | 0.001 149 | 0.140 84 | 828.70 | 1764.1 | 2592.8 | 830.30 | 1959.7 | 2790.6 | 2.2842 | 4.1850 | 6.4693 |
| 1.50 | 198.32 | 0.001 154 | 0.131 77 | 843.16 | 1751.3 | 2594.5 | 844.89 | 1947.3 | 2792.2 | 2.3150 | 4.1298 | 6.4448 |
| 1.75 | 205.76 | 0.001 166 | 0.113 49 | 876.46 | 1721.4 | 2597.8 | 878.50 | 1917.9 | 2796.4 | 2.3851 | 4.0044 | 6.3896 |
| 2.00 | 212.42 | 0.001 177 | 0.099 63 | 906.44 | 1693.8 | 2600.3 | 908.79 | 1890.7 | 2799.5 | 2.4474 | 3.8935 | 6.3409 |
| 2.25 | 218.45 | 0.001 187 | 0.088 75 | 933.83 | 1668.2 | 2602.0 | 936.49 | 1865.2 | 2801.7 | 2.5035 | 3.7937 | 6.2972 |
| 2.5 | 223.99 | 0.001 197 | 0.079 98 | 959.11 | 1644.0 | 2603.1 | 962.11 | 1841.0 | 2803.1 | 2.5547 | 3.7028 | 6.2575 |
| 3.00 | 233.90 | 0.001 217 | 0.066 68 | 1004.78 | 1599.3 | 2604.1 | 1008.42 | 1795.7 | 2804.2 | 2.6457 | 3.5412 | 6.1869 |
| 3.5 | 242.60 | 0.001 235 | 0.057 07 | 1045.43 | 1558.3 | 2603.7 | 1049.75 | 1753.7 | 2803.4 | 2.7253 | 3.4000 | 6.1253 |
| 4 | 250.40 | 0.001 252 | 0.049 78 | 1082.31 | 1520.0 | 2602.3 | 1087.31 | 1714.1 | 2801.4 | 2.7964 | 3.2737 | 6.0701 |
| 5 | 263.99 | 0.001 286 | 0.039 44 | 1147.81 | 1449.3 | 2597.1 | 1154.23 | 1640.1 | 2794.3 | 2.9202 | 3.0532 | 5.9734 |
| 6 | 275.64 | 0.001 319 | 0.032 44 | 1205.44 | 1384.3 | 2589.7 | 1213.35 | 1571.0 | 2784.3 | 3.0267 | 2.8625 | 5.8892 |
| 7 | 285.88 | 0.001 351 | 0.027 37 | 1257.55 | 1323.0 | 2580.5 | 1267.00 | 1505.1 | 2772.1 | 3.1211 | 2.6922 | 5.8133 |
| 8 | 295.06 | 0.001 384 | 0.023 52 | 1305.57 | 1264.2 | 2569.8 | 1316.64 | 1441.3 | 2758.0 | 3.2068 | 2.5364 | 5.7432 |
| 9 | 303.40 | 0.001 418 | 0.020 48 | 1350.51 | 1207.3 | 2557.8 | 1363.26 | 1378.9 | 2742.1 | 3.2858 | 2.3915 | 5.6772 |
| 10 | 311.06 | 0.001 452 | 0.018 026 | 1393.04 | 1151.4 | 2544.4 | 1407.56 | 1317.1 | 2724.7 | 3.3596 | 2.2544 | 5.6141 |
| 11 | 318.15 | 0.001 489 | 0.015 987 | 1433.7 | 1096.0 | 2529.8 | 1450.1 | 1255.5 | 2705.6 | 3.4295 | 2.1233 | 5.5527 |
| 12 | 324.75 | 0.001 527 | 0.014 263 | 1473.0 | 1040.7 | 2513.7 | 1491.3 | 1193.6 | 2684.9 | 3.4962 | 1.9962 | 5.4924 |
| 13 | 330.93 | 0.001 567 | 0.012 780 | 1511.1 | 985.0 | 2496.1 | 1531.5 | 1130.7 | 2662.2 | 3.5606 | 1.8718 | 5.4323 |
| 14 | 336.75 | 0.001 611 | 0.011 485 | 1548.6 | 928.2 | 2476.8 | 1571.1 | 1066.5 | 2637.6 | 3.6232 | 1.7485 | 5.3717 |
| 15 | 342.24 | 0.001 658 | 0.010 337 | 1585.6 | 869.8 | 2455.5 | 1610.5 | 1000.0 | 2610.5 | 3.6848 | 1.6249 | 5.3098 |
| 16 | 347.44 | 0.001 711 | 0.009 306 | 1622.7 | 809.0 | 2431.7 | 1650.1 | 930.6 | 2580.6 | 3.7461 | 1.4994 | 5.2455 |
| 17 | 352.37 | 0.001 770 | 0.008 364 | 1660.2 | 744.8 | 2405.0 | 1690.3 | 856.9 | 2547.2 | 3.8079 | 1.3698 | 5.1777 |
| 18 | 357.06 | 0.001 840 | 0.007 489 | 1698.9 | 675.4 | 2374.3 | 1732.0 | 777.1 | 2509.1 | 3.8715 | 1.2329 | 5.1044 |
| 19 | 361.54 | 0.001 924 | 0.006 657 | 1739.9 | 598.1 | 2338.1 | 1776.5 | 688.0 | 2464.5 | 3.9388 | 1.0839 | 5.0228 |
| 20 | 365.81 | 0.002 036 | 0.005 834 | 1785.6 | 507.5 | 2293.0 | 1826.3 | 583.4 | 2409.7 | 4.0139 | 0.9130 | 4.9269 |
| 21 | 369.89 | 0.002 207 | 0.004 952 | 1842.1 | 388.5 | 2230.6 | 1888.4 | 446.2 | 2334.6 | 4.1075 | 0.6938 | 4.8013 |
| 22 | 373.80 | 0.002 742 | 0.003 568 | 1961.9 | 125.2 | 2087.1 | 2022.2 | 143.4 | 2165.6 | 4.3110 | 0.2216 | 4.5327 |
| 22.09 | 374.14 | 0.003 155 | 0.003 155 | 2029.6 | 0.0 | 2029.6 | 2099.3 | 0.0 | 2099.3 | 4.4298 | 0.0 | 4.4298 |

$\hat{V}$ [=] $m^3/kg$; $\hat{U}$, $\hat{H}$ [=] J/g = kJ/kg; $\hat{S}$ [=] kJ/kg K

注意:背面有試題