UNIVERSITI SAINS MALAYSIA

Peperiksaan Kursus Semasa Cuti Panjang
Sidang Akademik 2002/2003

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EKC 125 – Termodinamik Kejuruteraan Kimia

Masa : 3 jam

Sila pastikan bahawa kertas peperiksaan ini mengandungi LIMA mukasurat yang bercetak dan DUA mukasurat Lampiran sebelum anda memulakan peperiksaan ini.

Kertas soalan ini mengandungi LIMA soalan. Jawab mana-mana EMPAT soalan.

Para pelajar boleh menjawab semua soalan dalam Bahasa Malaysia. Jika anda ingin menjawab dalam Bahasa Inggeris, anda hendaklah menjawab sekurang-kurangnya SATU soalan dalam Bahasa Malaysia.

1.   [a]   Air pada 28°C mengalir secara mantap di dalam paip lurus yang mendatar di mana tiada pertukaran haba atau kerja berlaku dengan persekitarannya. Halaju air ialah 15 ms^{-1} di dalam paip yang mempunyai diameter dalam 2.0 sm sehinggalah ke satu bahagian di mana diameternya meningkat secara mendadak. Anggap muatan haba malar untuk air ialah 4.18 kJ/kg°C.

[i]   Apakah perubahan suhu air jika diameter paip pada bahagian bawah arus ialah 3.8 sm?

[ii]   Apakah perubahan suhu air jika diameter paip pada bahagian bawah arus ialah 7.5 sm?

[iii] Apakah perubahan suhu maksimum untuk peningkatan diameter paip?

[11 markah]

[b]   Udara mengalir secara mantap pada kadar 0.4 kg/s melalui satu pemampat udara, udara memasuki pada 6 m/s dengan tekanan 1 bar dan isipadu spesifik 0.85 m^3/kg, dan keluar pada 4.5 m/s dengan tekanan 6.9 bar dan isipadu spesifik 0.16 m^3/kg. Tenaga dalam spesifik bagi udara yang keluar adalah 88 kJ/kg lebih tinggi daripada tenaga dalam spesifik udara yang masuk. Air penyejuk di dalam jaket yang mengelilingi silinder menyerap haba daripada udara pada kadar 59 kJ/s. Kira kuasa yang diperlukan oleh pemampat tersebut dan luas keratan rentas paip masuk dan keluar pemampat.

[14 markah]

1.   [a]   *Water at 28°C flows steadily in a straight horizontal pipe in which there is no exchange of either heat or work with the surroundings. Its velocity is 15 m s^{-1} in a pipe with an internal diameter of 2.0 cm until it flows into a section where the pipe diameter abruptly increases. Assume constant specific heat for water is 4.18 kJ/kg °C.*

[i]   *What is the temperature change of the water if the downstream diameter is 3.8 cm?*

[ii]   *What is the temperature change of the water if the downstream diameter is 7.5 cm?*

[iii] *What is the maximum temperature change for an enlargement in the pipe?*

[11 marks]

[b]   *Air flows steadily at the rate of 0.4 kg/s through an air compressor, entering at 6 m/s with a pressure of 1 bar and a specific volume of 0.85 m^3/kg, and leaving at 4.5 m/s with a pressure of 6.9 bar and a specific volume of 0.16 m^3/kg. The specific internal energy of the air leaving is 88 kJ/kg greater than that of the air entering. Cooling water in a jacket surrounding the cylinder absorbs heat from the air at the rate of 59 kJ/s. Calculate the power required to drive the compressor and the inlet and outlet pipe cross-sectional areas.*

[14 marks]

2. [a] Berikan dua penyataan penting tentang hukum kedua termodinamik.

[5 markah]

[b] Satu molar gas unggul dimampatkan secara sesuhu tetapi tidak boleh balik pada suhu 130°C dari 2.5 bar ke 6.5 bar di dalam satu alat omboh/silinder. Kerja yang di perlukan ialah 30 % melebihi kerja oleh mampatan sesuhu boleh balik. Haba yang dipindahkan dari gas semasa mampatan mengalir ke satu takungan haba pada 25°C.

Kirakan

[i] Perubahan entropi gas tersebut.

[7 markah]

[ii] Haba yang diserap oleh takungan

[7 markah]

[iii] ΔS_{jumlah}

[6 markah]

2. [a] *Give the two most important statements about second law of thermodynamics.*

[5 marks]

[b] *One mole of an ideal gas is compressed isothermally but irreversibly at 130°C from 2.5 bar to 6.5 bar in a piston / cylinder device. The work required is 30% greater than the work of reversible, isothermal compression. The heat transferred from the gas during compression flows to a heat reservoir at 25°C. Calculate:*

[i] *The entropy change of the gas*

[7 marks]

[ii] *The heat absorbed by the reservoir*

[7 marks]

[iii] *ΔS_{total}*

[6 marks]

3.   Terdapat gas ammonia di dalam bekas yang lejar dan tertebat baik. Tekanan awalnya ialah 20 lbf/in^2, jisimnya 0.12 lb dan isipadunya 2 kaki^3. Gas tersebut dikacau dengan roda pengayuh, lalu menghasilkan perubahan tenaga ke ammonia dengan magnitud 20 Btu. Andaikan gas ini adalah gas unggul, dan tentukan suhu terakhir bagi ammonia dalam °R. Abaikan kesan-kesan tenaga kinetik dan tenaga keupayaan.

Nota: Untuk ammonia

$$\frac{Cp}{R} = \left(3.591 + 0.274 \times 10^{-3}\, T + 2.576 \times 10^{-6}\, T^2 - 1.437 \times 10^{-9}\, T^3 + 0.2601 \times 10^{-12}\, T^4\right)$$

Di mana:
   T   = suhu, °R
   Cp   = muatan haba, ft.lb$_f$/lbmol, °R
   1 Btu = 778 ft.lb$_f$;   R = 1545 ft.lbf$_f$/lbmol, °R
   Berat molekul ammonia = 17

[25 markah]

3.   *Ammonia is contained in a rigid, well-insulated container. The initial pressure is 20 lbf/in^2, the mass is 0.12 lb, and the volume is 2 ft^3. The gas is stirred by a paddle wheel, resulting in an energy transfer to the ammonia of magnitude 20 Btu. Assuming an ideal gas, determine the final temperature of the ammonia, in °R. Neglect kinetic and potential energy effects.*

Note: For ammonia

$$\frac{Cp}{R} = \left(3.591 + 0.274 \times 10^{-3}\, T + 2.576 \times 10^{-6}\, T^2 - 1.437 \times 10^{-9}\, T^3 + 0.2601 \times 10^{-12}\, T^4\right)$$

   T   = temperature, °R
   Cp   = heat capacity, ft.lb$_f$/lbmol, °R
   1 Btu = 778 ft.lb$_f$;   R = 1545 ft.lbf$_f$/lbmol, °R
   Molecular weight of ammonia = 17

[25 marks]

4.   Stim memasuki turbin yang bertebat-baik pada keadaan mantap dengan kadar jisim 20 kg/s, suhu 320°C dan halaju 25 m/s. Stim keluar sebagai wap tepu pada 6 kPa dengan halaju 90 m/s. Abaikan kesan tenaga keupayaan dan tentukan tekanan salur masuk, dalam kPa, ketika turbin membentuk kuasa sebanyak 10 MW.
(Guna "Jadual-jadual stim")

[25 markah]

4.   *Steam enters a well-insulated turbine operating at steady state with a mass rate of 20 kg/s, temperature 320°C, and velocity 25 m/s. The steam exits as saturated vapor at 6 kPa with a velocity of 90 m/s. Neglecting potential energy effects, determine the inlet pressure, in kPa, while the turbine develops 10 MW of power.*
(Use the "Steam Tables")

[25 marks]

5.   Seorang pereka menyatakan yang kitaran kuasa ciptaannya boleh menghasilkan kuasa sebanyak 5 hp untuk kadar tambahan haba 400 Btu/min, pada keadaan mantap. Jika kitar tersebut beroperasi di antara takungan pada 2400 dan 1000°R, nilaikan kenyataan ini (tunjuk dengan pengiraan jika tuntutan ini berkemungkinan benar atau tidak).

     1 hp = 42.408 Btu/minit

[25 markah]

5.   *A new power cycle is claimed by its inventor to develop 5 hp for a heat addition rate of 400 Btu/min, at steady state. If the cycle operates between reservoirs at 2400 and 1000°R, evaluate this claim (show by calculations if the claim is possible or not)*

     1 hp = 42.408 Btu/minute

[25 marks]

-oooOooo-

Appendix

Table F.1: Saturated Steam, SI Units

V = SPECIFIC VOLUME $cm^3 g^{-1}$
U = SPECIFIC INTERNAL ENERGY $kJ\,kg^{-1}$
H = SPECIFIC ENTHALPY $kJ\,kg^{-1}$
S = SPECIFIC ENTROPY $kJ\,kg^{-1}\,K^{-1}$

			SPECIFIC VOLUME V			INTERNAL ENERGY U			ENTHALPY H			ENTROPY S		
t °C	T K	P kPa	sat. liq.	evap.	sat. vap.	sat. liq.	evap.	sat. vap.	sat. liq.	evap.	sat. vap.	sat. liq.	evap.	sat. vap.
0	273.15	0.611	1.000	206300.	206300.	-0.04	2375.7	2375.6	-0.04	2501.7	2501.6	0.0000	9.1578	9.1578
0.01	273.16	0.611	1.000	206200.	206200.	0.00	2375.6	2375.6	0.00	2501.6	2501.6	0.0000	9.1575	9.1575
1	274.15	0.657	1.000	192600.	192600.	4.17	2372.7	2376.9	4.17	2499.2	2503.4	0.0153	9.1158	9.1311
2	275.15	0.705	1.000	179900.	179900.	8.39	2369.9	2378.3	8.39	2496.8	2505.2	0.0306	9.0741	9.1047
3	276.15	0.757	1.000	168200.	168200.	12.60	2367.1	2379.7	12.60	2494.5	2507.1	0.0459	9.0326	9.0785
4	277.15	0.813	1.000	157300.	157300.	16.80	2364.3	2381.1	16.80	2492.1	2508.9	0.0611	8.9915	9.0526
5	278.15	0.872	1.000	147200.	147200.	21.01	2361.4	2382.4	21.01	2489.7	2510.7	0.0762	8.9507	9.0269
6	279.15	0.935	1.000	137800.	137800.	25.21	2358.6	2383.8	25.21	2487.4	2512.6	0.0913	8.9102	9.0014
7	280.15	1.001	1.000	129100.	129100.	29.41	2355.8	2385.2	29.41	2485.0	2514.4	0.1063	8.8699	8.9762
8	281.15	1.072	1.000	121000.	121000.	33.60	2353.0	2386.6	33.60	2482.6	2516.2	0.1213	8.8300	8.9513
9	282.15	1.147	1.000	113400.	113400.	37.80	2350.1	2387.9	37.80	2480.3	2518.1	0.1362	8.7903	8.9265
10	283.15	1.227	1.000	106400.	106400.	41.99	2347.3	2389.3	41.99	2477.9	2519.9	0.1510	8.7510	8.9020
11	284.15	1.312	1.000	99910.	99910.	46.18	2344.5	2390.7	46.19	2475.5	2521.7	0.1658	8.7119	8.8776
12	285.15	1.401	1.000	93830.	93840.	50.38	2341.7	2392.1	50.38	2473.2	2523.6	0.1805	8.6731	8.8536
13	286.15	1.497	1.001	88180.	88180.	54.56	2338.9	2393.4	54.57	2470.8	2525.4	0.1952	8.6345	8.8297
14	287.15	1.597	1.001	82900.	82900.	58.75	2336.1	2394.8	58.75	2468.5	2527.2	0.2098	8.5963	8.8060
15	288.15	1.704	1.001	77980.	77980.	62.94	2333.2	2396.2	62.94	2466.1	2529.1	0.2243	8.5582	8.7826
16	289.15	1.817	1.001	73380.	73380.	67.12	2330.4	2397.6	67.13	2463.8	2530.9	0.2388	8.5205	8.7593
17	290.15	1.936	1.001	69090.	69090.	71.31	2327.6	2398.9	71.31	2461.4	2532.7	0.2533	8.4830	8.7363
18	291.15	2.062	1.001	65090.	65090.	75.49	2324.8	2400.3	75.50	2459.0	2534.5	0.2677	8.4458	8.7135
19	292.15	2.196	1.002	61340.	61340.	79.68	2322.0	2401.7	79.68	2456.7	2536.4	0.2820	8.4088	8.6908
20	293.15	2.337	1.002	57840.	57840.	83.86	2319.2	2403.0	83.86	2454.3	2538.2	0.2963	8.3721	8.6684
21	294.15	2.485	1.002	54560.	54560.	88.04	2316.4	2404.4	88.04	2452.0	2540.0	0.3105	8.3356	8.6462
22	295.15	2.642	1.002	51490.	51490.	92.22	2313.6	2405.8	92.23	2449.6	2541.8	0.3247	8.2994	8.6241
23	296.15	2.808	1.002	48620.	48620.	96.40	2310.7	2407.1	96.41	2447.2	2543.6	0.3389	8.2634	8.6023
24	297.15	2.982	1.003	45920.	45930.	100.6	2307.9	2408.5	100.6	2444.9	2545.5	0.3530	8.2277	8.5806
25	298.15	3.166	1.003	43400.	43400.	104.8	2305.1	2409.9	104.8	2442.5	2547.3	0.3670	8.1922	8.5592
26	299.15	3.360	1.003	41030.	41030.	108.9	2302.3	2411.2	108.9	2440.2	2549.1	0.3810	8.1569	8.5379
27	300.15	3.564	1.003	38810.	38810.	113.1	2299.5	2412.6	113.1	2437.8	2550.9	0.3949	8.1218	8.5168
28	301.15	3.778	1.004	36730.	36730.	117.3	2296.7	2414.0	117.3	2435.4	2552.7	0.4088	8.0870	8.4959
29	302.15	4.004	1.004	34770.	34770.	121.5	2293.8	2415.3	121.5	2433.1	2554.5	0.4227	8.0524	8.4751
30	303.15	4.241	1.004	32930.	32930.	125.7	2291.0	2416.7	125.7	2430.7	2556.4	0.4365	8.0180	8.4546
31	304.15	4.491	1.005	31200.	31200.	129.8	2288.2	2418.0	129.8	2428.3	2558.2	0.4503	7.9839	8.4342
32	305.15	4.753	1.005	29570.	29570.	134.0	2285.4	2419.4	134.0	2425.9	2560.0	0.4640	7.9500	8.4140
33	306.15	5.029	1.005	28040.	28040.	138.2	2282.6	2420.8	138.2	2423.6	2561.8	0.4777	7.9163	8.3939
34	307.15	5.318	1.006	26600.	26600.	142.4	2279.7	2422.1	142.4	2421.2	2563.6	0.4913	7.8828	8.3740
35	308.15	5.622	1.006	25240.	25240.	146.6	2276.9	2423.5	146.6	2418.8	2565.4	0.5049	7.8495	8.3543
36	309.15	5.940	1.006	23970.	23970.	150.7	2274.1	2424.8	150.7	2416.4	2567.2	0.5184	7.8164	8.3348
37	310.15	6.274	1.007	22760.	22760.	154.9	2271.3	2426.2	154.9	2414.1	2569.0	0.5319	7.7835	8.3154
38	311.15	6.624	1.007	21630.	21630.	159.1	2268.4	2427.5	159.1	2411.7	2570.8	0.5453	7.7509	8.2962
39	312.15	6.991	1.007	20560.	20560.	163.3	2265.6	2428.9	163.3	2409.3	2572.6	0.5588	7.7184	8.2772
40	313.15	7.375	1.008	19550.	19550.	167.4	2262.8	2430.2	167.5	2406.9	2574.4	0.5721	7.6861	8.2583
41	314.15	7.777	1.008	18590.	18590.	171.6	2259.9	2431.6	171.6	2404.5	2576.2	0.5854	7.6541	8.2395
42	315.15	8.198	1.009	17690.	17690.	175.8	2257.1	2432.9	175.8	2402.1	2577.9	0.5987	7.6222	8.2209
43	316.15	8.639	1.009	16840.	16840.	180.0	2254.3	2434.2	180.0	2399.7	2579.7	0.6120	7.5905	8.2025
44	317.15	9.100	1.009	16040.	16040.	184.2	2251.4	2435.6	184.2	2397.3	2581.5	0.6252	7.5590	8.1842
45	318.15	9.582	1.010	15280.	15280.	188.3	2248.6	2436.9	188.4	2394.9	2583.3	0.6383	7.5277	8.1661
46	319.15	10.09	1.010	14560.	14560.	192.5	2245.7	2438.3	192.5	2392.5	2585.1	0.6514	7.4966	8.1481
47	320.15	10.61	1.011	13880.	13880.	196.7	2242.9	2439.6	196.7	2390.1	2586.9	0.6645	7.4657	8.1302
48	321.15	11.16	1.011	13230.	13230.	200.9	2240.0	2440.9	200.9	2387.7	2588.6	0.6776	7.4350	8.1125
49	322.15	11.74	1.012	12620.	12620.	205.1	2237.2	2442.3	205.1	2385.3	2590.4	0.6906	7.4044	8.0950
50	323.15	12.34	1.012	12040.	12050.	209.2	2234.3	2443.6	209.3	2382.9	2592.2	0.7035	7.3741	8.0776
51	324.15	12.96	1.013	11500.	11500.	213.4	2231.5	2444.9	213.4	2380.5	2593.9	0.7164	7.3439	8.0603
52	325.15	13.61	1.013	10980.	10980.	217.6	2228.6	2446.2	217.6	2378.1	2595.7	0.7293	7.3138	8.0432
53	326.15	14.29	1.014	10490.	10490.	221.8	2225.8	2447.6	221.8	2375.7	2597.5	0.7422	7.2840	8.0262
54	327.15	15.00	1.014	10020.	10020.	226.0	2222.9	2448.9	226.0	2373.2	2599.2	0.7550	7.2543	8.0093
55	328.15	15.74	1.015	9577.9	9578.9	230.2	2220.0	2450.2	230.2	2370.8	2601.0	0.7677	7.2248	7.9925
56	329.15	16.51	1.015	9157.7	9158.7	234.3	2217.2	2451.5	234.4	2368.4	2602.7	0.7804	7.1955	7.9759
57	330.15	17.31	1.016	8758.7	8759.8	238.5	2214.3	2452.8	238.5	2365.9	2604.5	0.7931	7.1663	7.9595
58	331.15	18.15	1.016	8379.8	8380.8	242.7	2211.4	2454.1	242.7	2363.5	2606.2	0.8058	7.1373	7.9431
59	332.15	19.02	1.017	8019.7	8020.8	246.9	2208.6	2455.4	246.9	2361.1	2608.0	0.8184	7.1085	7.9269
60	333.15	19.92	1.017	7677.5	7678.5	251.1	2205.7	2456.8	251.1	2358.6	2609.7	0.8310	7.0798	7.9108
61	334.15	20.86	1.018	7352.1	7353.2	255.3	2202.8	2458.1	255.3	2356.2	2611.4	0.8435	7.0513	7.8948
62	335.15	21.84	1.018	7042.7	7043.7	259.4	2199.9	2459.4	259.5	2353.7	2613.2	0.8560	7.0230	7.8790
63	336.15	22.86	1.019	6748.2	6749.3	263.6	2197.0	2460.7	263.6	2351.3	2614.9	0.8685	6.9948	7.8633
64	337.15	23.91	1.019	6468.0	6469.0	267.8	2194.1	2462.0	267.8	2348.8	2616.6	0.8809	6.9667	7.8477
65	338.15	25.01	1.020	6201.3	6202.3	272.0	2191.2	2463.2	272.0	2346.3	2618.4	0.8933	6.9388	7.8322
66	339.15	26.15	1.020	5947.2	5948.2	276.2	2188.3	2464.5	276.2	2343.9	2620.1	0.9057	6.9111	7.8168
67	340.15	27.33	1.021	5705.2	5706.2	280.4	2185.4	2465.8	280.4	2341.4	2621.8	0.9180	6.8835	7.8015
68	341.15	28.56	1.022	5474.6	5475.6	284.6	2182.5	2467.1	284.6	2338.9	2623.5	0.9303	6.8561	7.7864
69	342.15	29.84	1.022	5254.8	5255.8	288.8	2179.6	2468.4	288.8	2336.4	2625.2	0.9426	6.8288	7.7714
70	343.15	31.16	1.023	5045.2	5046.3	292.9	2176.7	2469.7	293.0	2334.0	2626.9	0.9548	6.8017	7.7565
71	344.15	32.53	1.023	4845.4	4846.4	297.1	2173.8	2470.9	297.2	2331.5	2628.6	0.9670	6.7747	7.7417
72	345.15	33.96	1.024	4654.7	4655.7	301.3	2170.9	2472.2	301.4	2329.0	2630.3	0.9792	6.7478	7.7270
73	346.15	35.43	1.025	4472.7	4473.7	305.5	2168.0	2473.5	305.5	2326.5	2632.0	0.9913	6.7211	7.7124
74	347.15	36.96	1.025	4299.0	4300.0	309.7	2165.1	2474.8	309.7	2324.0	2633.7	1.0034	6.6945	7.6979

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

TEMPERATURE: $t\,^{\circ}C$
(TEMPERATURE: T kelvins)

P/kPa ($t^{sat}/^{\circ}C$)		sat. liq.	sat. vap.	200 (473.15)	225 (498.15)	250 (523.15)	275 (548.15)	300 (573.15)	325 (598.15)	350 (623.15)	375 (648.15)
1350 (193.35)	V	1.146	145.74	148.79	159.70	169.96	179.79	189.33	198.66	207.85	216.93
	U	820.944	2589.9	2603.9	2653.6	2700.1	2744.4	2787.4	2829.5	2871.1	2912.5
	H	822.491	2786.6	2804.7	2869.2	2929.5	2987.1	3043.0	3097.7	3151.7	3205.4
	S	2.2676	6.4780	6.5165	6.6493	6.7675	6.8750	6.9746	7.0681	7.1566	7.2410
1400 (195.04)	V	1.149	140.72	142.94	153.57	163.55	173.08	182.32	191.35	200.24	209.02
	U	828.465	2590.8	2601.3	2651.7	2698.6	2743.2	2786.4	2828.6	2870.4	2911.9
	H	830.074	2787.8	2801.4	2866.7	2927.6	2985.5	3041.6	3096.5	3150.7	3204.5
	S	2.2837	6.4651	6.4941	6.6285	6.7477	6.8560	6.9561	7.0499	7.1386	7.2233
1450 (196.69)	V	1.151	136.04	137.48	147.86	157.57	166.83	175.79	184.54	193.15	201.65
	U	835.791	2591.6	2598.7	2649.7	2697.1	2742.0	2785.4	2827.8	2869.7	2911.3
	H	837.460	2788.9	2798.1	2864.1	2925.5	2983.9	3040.3	3095.4	3149.7	3203.6
	S	2.2993	6.4526	6.4722	6.6082	6.7286	6.8376	6.9381	7.0322	7.1212	7.2061
1500 (198.29)	V	1.154	131.66	132.38	142.53	151.99	161.00	169.70	178.19	186.53	194.77
	U	842.933	2592.4	2596.1	2647.7	2695.5	2740.8	2784.4	2826.9	2868.9	2910.6
	H	844.663	2789.9	2794.7	2861.5	2923.5	2982.3	3038.9	3094.2	3148.7	3202.8
	S	2.3145	6.4406	6.4508	6.5885	6.7099	6.8196	6.9207	7.0152	7.1044	7.1894
1550 (199.85)	V	1.156	127.55	127.61	137.54	146.77	155.54	164.00	172.25	180.34	188.33
	U	849.901	2593.2	2593.5	2645.8	2694.0	2739.5	2783.4	2826.1	2868.2	2910.0
	H	851.694	2790.8	2791.3	2858.9	2921.5	2980.6	3037.6	3093.1	3147.7	3201.9
	S	2.3292	6.4289	6.4298	6.5692	6.6917	6.8022	6.9038	6.9986	7.0881	7.1733
1600 (201.37)	V	1.159	123.69	....	132.85	141.87	150.42	158.66	166.68	174.54	182.30
	U	856.707	2593.8	....	2643.7	2692.4	2738.2	2782.4	2825.2	2867.5	2909.3
	H	858.561	2791.7	....	2856.3	2919.4	2979.0	3036.2	3091.9	3146.7	3201.0
	S	2.3436	6.4175	....	6.5503	6.6740	6.7852	6.8873	6.9825	7.0723	7.1577
1650 (202.86)	V	1.161	120.05	....	128.45	137.27	145.61	153.64	161.44	169.09	176.63
	U	863.359	2594.5	....	2641.7	2690.9	2737.1	2781.3	2824.4	2866.7	2908.7
	H	865.275	2792.6	....	2853.6	2917.4	2977.3	3034.8	3090.8	3145.7	3200.1
	S	2.3576	6.4065	....	6.5319	6.6567	6.7687	6.8713	6.9669	7.0569	7.1425
1750 (205.72)	V	1.166	113.38	....	120.39	128.85	136.82	144.45	151.87	159.12	166.27
	U	876.234	2595.7	....	2637.6	2687.7	2734.5	2779.3	2822.7	2865.3	2907.4
	H	878.274	2794.1	....	2848.2	2913.2	2974.0	3032.1	3088.4	3143.7	3198.4
	S	2.3846	6.3853	....	6.4961	6.6233	6.7368	6.8405	6.9368	7.0273	7.1133
1800 (207.11)	V	1.168	110.32	....	116.69	124.99	132.78	140.24	147.48	154.55	161.51
	U	882.472	2596.3	....	2635.5	2686.1	2733.3	2778.2	2821.8	2864.5	2906.7
	H	884.574	2794.8	....	2845.5	2911.0	2972.3	3030.7	3087.3	3142.7	3197.5
	S	2.3976	6.3751	....	6.4787	6.6071	6.7214	6.8257	6.9223	7.0131	7.0993
1850 (208.47)	V	1.170	107.41	....	113.19	121.33	128.96	136.26	143.33	150.23	157.02
	U	888.585	2596.8	....	2633.3	2684.4	2732.0	2777.2	2820.9	2863.8	2906.1
	H	890.750	2795.5	....	2842.8	2908.9	2970.6	3029.3	3086.1	3141.7	3196.6
	S	2.4103	6.3651	....	6.4616	6.5912	6.7064	6.8112	6.9082	6.9993	7.0856
1900 (209.80)	V	1.172	104.65	....	109.87	117.87	125.35	132.49	139.39	146.14	152.76
	U	894.580	2597.3	....	2631.2	2682.8	2730.7	2776.2	2820.1	2863.0	2905.4
	H	896.807	2796.1	....	2840.0	2906.7	2968.8	3027.9	3084.9	3140.7	3195.7
	S	2.4228	6.3554	....	6.4448	6.5757	6.6917	6.7970	6.8944	6.9857	7.0723
1950 (211.10)	V	1.174	102.031	....	106.72	114.58	121.91	128.90	135.66	142.25	148.72
	U	900.461	2597.7	....	2629.0	2681.1	2729.4	2775.1	2819.2	2862.3	2904.8
	H	902.752	2796.7	....	2837.1	2904.6	2967.1	3026.5	3083.7	3139.7	3194.8
	S	2.4349	6.3459	....	6.4283	6.5604	6.6772	6.7831	6.8809	6.9725	7.0593
2000 (212.37)	V	1.177	99.536	....	103.72	111.45	118.65	125.50	132.11	138.56	144.89
	U	906.236	2598.2	....	2626.9	2679.5	2728.1	2774.0	2818.3	2861.5	2904.1
	H	908.589	2797.2	....	2834.3	2902.4	2965.4	3025.0	3082.5	3138.6	3193.9
	S	2.4469	6.3366	....	6.4120	6.5454	6.6631	6.7696	6.8677	6.9596	7.0466
2100 (214.85)	V	1.181	94.890	....	98.147	105.64	112.59	119.18	125.53	131.70	137.76
	U	917.479	2598.9	....	2622.4	2676.1	2725.4	2771.9	2816.5	2860.0	2902.8
	H	919.959	2798.2	....	2828.5	2897.9	2961.9	3022.2	3080.1	3136.6	3192.1
	S	2.4700	6.3187	....	6.3802	6.5162	6.6356	6.7432	6.8422	6.9347	7.0220
2200 (217.24)	V	1.185	90.652	....	93.067	100.35	107.07	113.43	119.53	125.47	131.28
	U	928.346	2599.6	....	2617.9	2672.7	2722.7	2769.7	2814.7	2858.5	2901.5
	H	930.953	2799.1	....	2822.7	2893.4	2958.3	3019.3	3077.7	3134.5	3190.3
	S	2.4922	6.3015	....	6.3492	6.4879	6.6091	6.7179	6.8177	6.9107	6.9985
2300 (219.55)	V	1.189	86.769	....	88.420	95.513	102.03	108.18	114.06	119.77	125.36
	U	938.866	2600.2	....	2613.3	2669.2	2720.0	2767.6	2812.9	2857.0	2900.2
	H	941.601	2799.8	....	2816.7	2888.9	2954.7	3016.4	3075.3	3132.4	3188.5
	S	2.5136	6.2849	....	6.3190	6.4605	6.5835	6.6935	6.7941	6.8877	6.9759