

UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang Akademik 1994/95

April 1995

EKC 225 - TERMODINAMIK KEJURUTERAAN KIMIA

Masa: [3 Jam]

ARAHAN KEPADA CALON:

Sila pastikan kertas soalan ini mengandungi **ENAM** (6) muka surat dan **EMPAT** (4) lampiran bercetak sebelum anda memulakan peperiksaan.

Kertas ini mengandungi **LIMA** (5) soalan.

Jawab **EMPAT** (4) soalan. Soalan nombor 1 dan nombor 2 adalah diwajibkan dan pilih mana-mana dua soalan dari nombor 3, 4 dan 5.

Soalan No. 2 **MESTI** dijawab dalam Bahasa Malaysia. Anda dibolehkan menjawab soalan-soalan lain dalam Bahasa Inggeris.

Soalan terjemahan Bahasa Inggeris ditaip dalam bentuk tulisan **Italic**.

..2/-

Jawab soalan no. 1 dan no. 2

1. Jawab yang berikut dengan jelas tetapi ringkas:
Answer the followings clearly but very briefly :

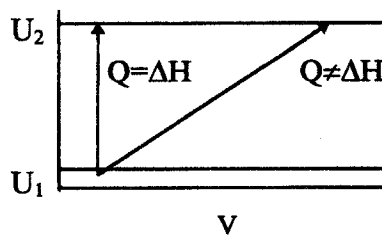
- [a] Air mempunyai titik tripel 0.01°C dan 0.001 bar. Jelaskan keadaan ini dengan menggunakan hukum-hukum fasa.

Water has a triple point at 0.01°C and 0.001 bar. Describe the physical meaning of that using the Phase Rule.

(3 markah)

- [b] Bincangkan rajah berikut.

Discuss the shown figure.



(4 markah)

- [c] Dengan menggunakan definisi Entalpi, terbitkan hubungan antara C_p dan C_v untuk gas unggul.

Using the definition of enthalpy, derive the well known relationship between C_p and C_v for ideal gas.

(4 markah)

- [d] Dengan memberikan contoh, jelaskan bagaimana anda mengira haba pembentukan piawai suatu sebatian daripada ukuran haba pembakaran piawai.

Describe with an example how can you calculate the standard heat of formation of a compound from the measured standard heat of combustion.

(5 markah)

- [e] Takrifkan proses yang berikut:

Define the processes described by :

$$\Delta S = 0, \Delta S > 0, \Delta S < 0, Q = \Delta H, Q - W_s = \Delta H.$$

(5 markah)

- [f] Tunjukkan Kitaran Karnot pada Rajah T-S. Bincangkan masalah-masalah yang mungkin timbul dalam penggunaan kitaran yang ideal itu. Dengan menggunakan Rajah T-S, tunjukkan bagaimana anda menyelesaikan masalah-masalah tersebut dengan menggunakan Kitaran Rankine.

Show on a T-S diagram the Carnot Cycle. Discuss the problems that may arise in applying such ideal cycle. Show on a T-S diagram how can you resolve these problems by employing the Rankine Cycle.

(5 markah)

- [g] Nyatakan yang mana diantara yang berikut bergantung keadaan laluan: Tekanan, haba, entalpi, suhu, entropi, ketumpatan, kerja dan kelikatan.

*State which of the following properties are path functions :
Pressure, heat, enthalpy, temperature, entropy, density, work, viscosity.*

(4 markah)

2. Satu gas unggul dimampatkan daripada 1 bar dan 20°C kepada 10 bar dan 35°C. Kirakan Q , W , ΔU , ΔS dengan mengandaikan kedua-dua laluan berikut (komen nilai-nilai yang dikira laluan):

An ideal gas is compressed from 1 bar and 20°C to 10 bar and 35°C. Calculate Q , W , ΔU , ΔS assuming the following two paths (Comments on the calculated values in the two paths) :

- [a] Mampatan Isotermal pada 20°C diikuti oleh pemanasan Isobaric (tekanan tetap).

Isothermal compression at 20°C followed by isobaric heating (constant pressure).

- [b] Mampatan adiabatik diikuti oleh penyejukan isobaric.

Adiabatic compression followed by isobaric cooling

$$C_v = 18 \text{ J/mol K} \quad C_p = 26.314 \text{ J/mol K}$$

(30 markah)

Jawab mana-mana DUA soalan

Answer only TWO questions

3. Tindakbalas penyahhidrogenan butena kepada butadiena adalah suatu tindakbalas endotermik:

The dehydrogenation of butene to butadiene is an endothermic reaction :



Tindakbalas tersebut dilakukan pada tekanan atmosfera dimana haba bersamaan dengan 30000 J/s ditambah. Kadar aliran Butena ialah 1.0 mol/s dan stim 10.0 mol/s disatukan dengan butena sebagai suap kepada reaktor pada suhu 900 K dan pada tekanan atmosfera. Berapakah suhu hasil keluaran (effluent temperature) apabila 20% daripada butena telah bertukar.

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The reaction is to be carried out at atmospheric pressure with the addition of heat equal to 30000 J/s. Butene flow rate was 1.0 mole /s, however 10.0 mole /s of steam was introduced with the butene as a feed to the reactor at a temperature of 900 K and atmospheric pressure. What will be the effluent temperature when 20% of the butene has been converted.

	C_p (kJ /kmol K)	H_{298}^f (kJ /kmol)
Butene	148.7	-130
Butadiene	131.2	110200
Steam	36.6	-----
Hydrogen	29.4	0

(20 markah)

4. Dalam pembuatan asid sulfurik, SO_2 ditukarkan menjadi SO_3 bahan tindakbalas di dalam sebuah alat penukar bermangkin. Jika kandungan suap kepada alat penukar tersebut ialah 15 mol % SO_2 , 20 mol % O_2 , dan 65 mol % N_2 pada 1 bar dan $480^\circ C$, maka:

In the manufacturing of sulfuric acid, SO_2 is converted into SO_3 in a catalytic converter. If the feed to the converter is composed of 15 mole % SO_2 , 20 mole % O_2 , and 65 mole % N_2 and it is at 1 bar and $480^\circ C$, then :

- [a] Kirakan penukaran SO_2 pada keadaan seimbang dimana haba yang dipindahkan daripada reaktor mesti dikeluarkan supaya suhu tetap pada $480^\circ C$. Andaikan ΔH tidak berubah dan tindakbalas campuran sebagai percampuran gas yang ideal.

Calculate the equilibrium conversion of SO_2 and the heat that must be removed from the reactor to maintain its temperature at $480^\circ C$. You may notice that ΔH may be assumed constant. You may also assume the reaction mixture as an ideal gas mixture.

$$\Delta G_{298}^\circ = -70860 \text{ J/mol}, \Delta H_{298}^\circ = -98890 \text{ J/mol}, \Delta H_{753}^\circ = -98353 \text{ J/mol}$$

- [b] Nyatakan pengubahsuaian yang perlu untuk jawapan tersebut jika ΔH berubah mengikut suhu.

State what modification is required for the solution if ΔH varies significantly with temperature.

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[c] Nyatakan pengubahsuaian yang perlu jika tindakbalas campuran tidak ideal.

State what modification is required if the reaction mixture can not be assumed ideal.

(20 markah)

5. Stim tepu pada 175kPa dimampatkan di dalam sebuah pemampat empat kepada 650 kPa pada kadar 1.5 kg/s. Kecekapan pemampat ialah 75%. Dengan menggunakan jadual stim, kirakan tenaga yang diperlukan oleh pemampat itu, dan kirakan juga entalpi dan entropi stim yang keluar.

Saturated steam at 175 kPa is compressed adiabatically in a centrifugal compressor to 650 kPa at a rate of 1.5 kg /s. The compressor efficiency is 75%. Using the steam table, calculate the power requirement for the compressor. Calculate also the enthalpy and entropy of the exit steam.

(20 markah)

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ABS PRESS (KPA DEG C)	SAT WATER	SAT STEAM	TEMPERATURE, DEG C (TEMPERATURE, °F)							
			300 (573.15)	350 (623.15)	400 (673.15)	450 (723.15)	500 (773.15)	550 (823.15)	600 (873.15)	650 (923.15)
1 (0.08)	1.000 29.334 29.335 0.1080	129200 2305.2 2614.4 8.9767	264500 2812.3 3076.8 10.3450	287500 2889.9 3117.5 10.6133	310660 2969.1 3278.7 10.6711	333730 3049.9 3303.5 10.8200	356810 3132.4 3489.2 10.9612	379880 3216.7 3595.5 11.0957	402960 3216.6 3705.6 11.2243	426040 3390.3 3816.4 11.3476
10 (0.68)	1.010 191.822 191.832 0.6493	14670 2436.0 2584.8 8.1811	26440 2812.2 3076.6 9.2820	28750 2889.8 3117.3 9.4904	31060 2969.0 3279.6 9.6083	33370 3049.8 3303.5 9.7672	35670 3132.3 3489.1 9.8984	37980 3216.6 3595.6 10.0329	40290 3302.6 3705.6 10.1616	42600 3390.3 3816.3 10.2849
20 (0.09)	1.017 251.432 251.453 0.6321	7649.8 2466.9 2609.9 7.9094	13210 2812.0 3076.4 8.9618	14370 2889.6 3117.1 9.1303	15520 2969.9 3279.4 9.2882	16680 3049.7 3303.4 9.4372	17830 3132.3 3489.0 9.5784	18990 3216.5 3595.4 9.7130	20140 3302.5 3705.4 9.8416	21300 3390.2 3816.2 9.9650
30 (0.12)	1.022 299.271 299.302 0.6441	5229.3 2468.6 2626.4 7.7695	8810.8 2811.8 3076.1 8.7744	9581.2 2889.5 3176.9 8.9430	10350 2969.7 3279.3 9.1010	11120 3049.5 3303.3 9.2499	11890 3132.2 3488.9 9.3912	12660 3216.5 3595.3 9.5257	13430 3302.5 3705.4 9.6644	14190 3390.1 3816.1 9.7778
40 (0.09)	1.027 317.609 317.650 0.6561	3993.4 2477.1 2636.9 7.6709	5605.5 2811.6 3076.9 8.6413	7184.6 2889.4 3176.8 8.8100	7762.5 2969.6 3279.1 8.9680	8340.1 3049.6 3303.1 9.1170	8917.6 3132.1 3488.8 9.2583	9494.9 3216.4 3595.2 9.3929	10070 3302.4 3705.3 9.5216	10640 3390.1 3816.1 9.6450
50 (0.36)	1.030 340.813 340.864 1.0912	3240.2 2484.0 2648.0 7.5947	5283.9 2811.6 3076.1 8.6380	6748.7 2889.2 3176.6 8.7068	7209.1 2969.6 3279.0 8.8649	7671.4 3049.4 3303.0 9.0139	8132.6 3132.0 3488.7 9.1552	8595.5 3216.3 3595.1 9.2898	9057.4 3302.3 3705.2 9.4186	9519.2 3390.1 3816.0 9.5419
75 (0.79)	1.037 394.374 394.451 1.2131	2216.9 2499.7 2663.0 7.4570	3520.5 2811.0 3076.1 8.3502	3879.4 2888.9 3176.1 8.5191	4138.0 2969.2 3278.6 8.6773	4486.4 3049.2 3302.7 8.8265	4754.7 3131.8 3488.4 8.9678	5062.8 3216.1 3595.8 9.1025	5370.9 3302.2 3705.0 9.2312	5678.9 3389.9 3815.9 9.3546
100 (0.63)	1.043 417.405 417.511 1.3027	1693.7 2505.1 2675.4 7.3596	2638.7 2810.6 3074.5 8.2165	2870.8 2888.6 3175.6 8.3858	3102.5 2969.0 3278.2 8.5442	3334.0 3049.0 3302.4 8.6934	3565.3 3131.6 3488.1 8.8348	3796.5 3216.0 3595.6 8.9695	4027.7 3302.0 3704.8 9.0982	4258.8 3389.8 3815.7 9.2217

101.325	V	1.044	1673.0	2604.2	2833.2	3061.9	2290.3	3518.7	3746.9	3976.0	4203.1
(100.00)	U	418.969	2606.6	2810.6	2896.6	2966.0	3048.9	3131.6	3215.9	3302.0	3389.9
	H	419.064	2676.0	3074.4	3175.6	3278.2	3362.3	3468.1	3605.6	3704.8	3815.7
	S	1.3069	7.3664	8.2105	8.3797	8.5381	8.6873	8.8287	8.9634	9.0922	9.2166
125	V	1.049	1374.6	2109.7	2295.6	2481.7	2666.5	2851.7	3036.6	3221.8	3405.7
(105.99)	U	444.224	2513.4	2810.2	2896.2	2967.7	3048.7	3131.4	3215.8	3301.9	3389.9
	H	444.366	2686.2	3073.9	3175.2	3277.8	3362.0	3487.9	3695.4	3704.6	3815.7
	S	1.3740	7.2847	8.1129	8.2823	8.4408	8.5901	8.7316	8.8663	8.9961	9.1186
150	V	1.053	1159.0	1757.0	1912.2	2066.9	2221.5	2375.9	2530.2	2684.6	2838.6
(111.37)	U	466.966	2519.6	2809.7	2867.9	2967.4	3048.6	3131.2	3215.6	3301.7	3389.9
	H	467.126	2693.4	3073.3	3174.7	3277.5	3361.7	3487.6	3695.1	3704.4	3815.7
	S	1.4336	7.2234	8.0280	8.1976	8.3662	8.5066	8.6472	8.7819	8.9108	9.0343
175	V	1.057	1003.34	1505.1	1638.3	1771.1	1903.7	2036.1	2168.4	2300.7	2432.9
(116.06)	U	466.816	2524.7	2809.3	2867.6	2967.1	3048.3	3131.0	3215.4	3301.6	3389.9
	H	487.000	2700.3	3072.7	3174.2	3277.1	3361.4	3487.3	3694.9	3704.2	3815.1
	S	1.4849	7.1716	7.9661	8.1259	8.2847	8.4341	8.5758	8.7105	8.8394	8.9630
200	V	1.061	885.44	1316.2	1432.8	1549.2	1665.3	1781.2	1897.1	2012.9	2128.6
(120.23)	U	504.489	2529.2	2808.8	2867.2	2966.9	3048.0	3130.8	3216.3	3301.4	3389.9
	H	504.701	2706.3	3072.1	3173.8	3276.7	3361.1	3487.0	3694.7	3704.0	3815.0
	S	1.5301	7.1268	7.8937	8.0638	8.2226	8.3722	8.5139	8.6487	8.7776	8.9012
225	V	1.064	792.97	1159.2	1273.1	1376.6	1479.9	1583.0	1686.0	1789.0	1891.9
(123.99)	U	520.466	2533.2	2808.4	2866.9	2966.6	3047.8	3130.6	3216.1	3301.2	3389.9
	H	520.706	2711.6	3071.5	3173.3	3276.3	3360.8	3486.8	3694.4	3703.8	3814.8
	S	1.5706	7.0673	7.8385	8.0088	8.1679	8.3176	8.4693	8.6142	8.7231	8.8487
250	V	1.068	718.44	1061.6	1146.2	1238.5	1331.5	1424.4	1517.2	1609.9	1702.6
(127.43)	U	536.077	2536.8	2808.0	2866.5	2966.3	3047.6	3130.4	3214.9	3301.1	3389.9
	H	536.343	2716.4	3070.9	3172.8	3276.9	3360.4	3486.5	3694.2	3703.6	3814.6
	S	1.6071	7.0620	7.7891	7.9697	8.1188	8.2686	8.4104	8.5453	8.6743	8.7980
275	V	1.071	657.04	966.46	1040.7	1125.6	1210.2	1294.7	1379.0	1463.3	1547.6
(130.60)	U	548.564	2540.0	2807.5	2866.2	2966.0	3047.3	3130.2	3214.7	3300.9	3389.9
	H	548.866	2720.7	3070.3	3172.4	3276.6	3360.1	3486.2	3694.0	3703.4	3814.4
	S	1.6407	7.0201	7.7444	7.9151	8.0744	8.2243	8.3661	8.5011	8.6301	8.7638
300	V	1.073	606.66	875.29	953.62	1031.4	1109.0	1186.6	1263.9	1341.2	1418.6
(133.64)	U	561.107	2543.0	2807.1	2866.8	2966.6	3047.1	3130.0	3214.6	3300.8	3389.9
	H	561.429	2724.7	3069.7	3171.9	3276.2	3379.8	3486.0	3693.7	3703.2	3814.2
	S	1.6716	6.9909	7.7034	7.8744	8.0338	8.1836	8.3257	8.4608	8.5898	8.7136

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TABLE C.2. SUPERHEATED STEAM SI UNITS (Continued)

ABS PRESS kPa (SAT TEMP) DEG C	SAT WATER	SAT STEAM	TEMPERATURE DEG C (TEMPERATURE, K)										
			150 (423.15)	175 (448.15)	200 (473.15)	220 (493.15)	240 (513.15)	260 (533.15)	280 (553.15)	300 (578.15)			
325 (136.29)	U 1.076 V 572.847 H 573.197 S 1.7004	561.75 2545.7 2728.3 6.9640	583.58 2568.7 2758.4 7.0363	622.41 2609.6 2811.9 7.1592	650.22 2649.6 2864.2 7.2729	719.81 2712.7 2946.6 7.4400	749.18 2744.0 2987.5 7.5181	778.39 2775.3 3028.2 7.5933	807.47 2806.6 3069.0 7.6657				
350 (138.87)	U 1.079 V 583.892 H 584.270 S 1.7273	524.00 2548.2 2731.6 6.9392	540.58 2567.1 2766.3 6.9982	576.90 2608.3 2810.3 7.1222	640.18 2680.4 2904.5 7.3226	667.75 2712.0 2945.7 7.4045	695.09 2743.4 2986.7 7.4828	722.27 2774.8 3027.6 7.5581	749.33 2806.2 3068.4 7.6307				
375 (141.31)	U 1.081 V 594.372 H 594.737 S 1.7526	491.13 2550.5 2734.7 6.9180	503.29 2565.4 2754.1 6.9624	537.46 2607.1 2808.6 7.0875	596.81 2679.6 2903.4 7.2891	622.62 2711.3 2944.8 7.3713	648.22 2742.8 2985.9 7.4499	673.64 2774.3 3026.9 7.5254	698.94 2806.7 3067.8 7.5981				
400 (143.62)	U 1.084 V 604.237 H 604.670 S 1.7764	462.22 2552.7 2737.6 6.8943	470.66 2563.7 2752.0 6.9285	502.93 2605.8 2807.0 7.0648	558.85 2678.8 2902.3 7.2576	583.14 2710.6 2943.9 7.3402	607.20 2742.2 2985.1 7.4190	631.09 2773.7 3026.2 7.4947	654.86 2806.3 3067.2 7.5675				
425 (145.82)	U 1.086 V 613.667 H 614.128 S 1.7990	436.61 2564.8 2740.3 6.8739	441.89 2562.0 2749.8 6.9065	472.47 2604.5 2805.3 7.0239	525.36 2678.0 2901.2 7.2280	548.30 2709.9 2942.9 7.3108	571.01 2741.6 2984.3 7.3899	593.54 2773.2 3025.5 7.4657	615.95 2804.8 3066.6 7.5388				
450 (147.92)	U 1.088 V 622.672 H 623.162 S 1.8204	413.75 2556.7 2742.9 6.8547	416.24 2560.3 2747.7 6.8860	445.38 2603.2 2803.7 6.9946	495.89 2677.1 2900.2 7.1999	517.33 2709.2 2942.0 7.2831	538.83 2741.0 2983.5 7.3624	560.17 2772.7 3024.8 7.4384	581.37 2804.4 3065.0 7.5116				
475 (149.92)	U 1.091 V 631.294 H 631.812 S 1.8408	393.22 2558.5 2745.3 6.8365	393.31 2558.6 2745.5 6.8660	421.14 2601.9 2802.0 6.9667	468.95 2676.3 2899.1 7.1732	489.62 2708.6 2941.1 7.2667	510.05 2740.4 2982.7 7.3363	530.30 2772.2 3024.1 7.4125	550.43 2803.9 3065.4 7.4868				
500 (151.84)	U 1.093 V 639.569 H 640.116 S 1.8604	374.68 2560.2 2747.5 6.8192	374.68 2560.2 2747.5 6.8490	399.31 2600.3 2800.3 6.9400	444.97 2675.5 2898.0 7.1478	464.67 2707.8 2940.1 7.2317	484.14 2739.8 2981.9 7.3115	503.43 2771.7 3023.4 7.3879	522.58 2803.5 3064.8 7.4614				

525 (153.69)	V U H S	1.095 647.528 648.103 1.8790	357.84 2561.8 2749.7 6.8027	379.56 2599.3 2798.6 6.9145	404.13 2641.6 2853.8 7.0345	423.28 2674.6 2896.8 7.1236	442.11 2707.1 2939.2 7.2078	460.70 2739.2 2981.1 7.2879	479.11 2771.2 3022.2 7.3645	497.38 2803.0 3064.1 7.4381
550 (165.47)	V U H S	1.097 655.199 655.802 1.8970	342.48 2563.3 2751.7 6.7870	361.60 2598.0 2796.8 6.8900	385.19 2640.6 2852.5 7.0108	403.55 2673.8 2895.7 7.1004	421.59 2706.4 2938.3 7.1849	439.38 2770.6 2980.3 7.2653	457.00 2802.6 3022.0 7.3421	474.48 2802.6 3063.5 7.4158
575 (157.18)	V U H S	1.099 662.603 663.235 1.9142	328.41 2564.8 2753.6 6.7720	345.20 2596.6 2795.1 6.8664	367.90 2639.6 2851.1 6.9880	385.54 2672.9 2894.6 7.0781	402.85 2705.7 2937.3 7.1630	419.92 2738.0 2979.5 7.2436	436.81 2770.1 3021.3 7.3205	453.56 2802.1 3062.9 7.3945
600 (158.84)	V U H S	1.101 669.762 670.423 1.9308	315.47 2566.2 2755.5 6.7575	330.16 2595.3 2793.3 6.8437	352.04 2638.5 2849.7 6.9662	369.03 2672.1 2891.5 7.0567	386.88 2705.0 2935.4 7.1419	402.08 2737.4 2978.7 7.2228	418.31 2769.6 3020.6 7.3000	434.39 2801.6 3062.3 7.3740
625 (160.44)	V U H S	1.103 676.695 677.364 1.9469	303.54 2567.5 2757.2 6.7437	316.31 2593.9 2791.6 6.8217	337.45 2637.5 2848.4 6.9451	353.83 2671.2 2892.3 7.0361	369.87 2704.2 2936.4 7.1217	385.67 2736.8 2977.8 7.2028	401.28 2769.1 3019.9 7.2802	416.75 2801.2 3061.7 7.3544
650 (161.99)	V U H S	1.105 683.417 684.135 1.9623	292.49 2568.7 2758.9 6.7304	303.53 2592.5 2789.8 6.8004	323.98 2636.4 2847.0 6.9247	339.80 2670.3 2891.2 7.0162	355.29 2703.5 2934.4 7.1021	370.52 2736.2 2977.0 7.1835	385.56 2768.5 3019.2 7.2611	400.47 2800.7 3061.0 7.3365
675 (163.49)	V U H S	1.106 689.943 690.689 1.9773	282.23 2570.0 2760.5 6.7176	291.69 2591.1 2788.0 6.7798	311.51 2635.4 2845.6 6.9050	326.81 2669.5 2890.1 6.9970	341.78 2702.8 2933.5 7.0833	356.49 2735.6 2976.2 7.1650	371.01 2768.0 3018.5 7.2428	385.39 2800.3 3060.4 7.3173
700 (164.96)	V U H S	1.108 696.285 697.061 1.9918	272.68 2571.1 2762.0 6.7062	280.69 2589.7 2786.2 6.7698	299.92 2634.3 2844.2 6.8859	314.75 2668.6 2888.9 6.9784	329.23 2702.1 2932.5 7.0651	343.46 2735.0 2975.4 7.1470	357.50 2767.5 3017.7 7.2250	371.39 2799.8 3059.8 7.2997
725 (166.38)	V U H S	1.110 702.457 703.261 2.0059	263.77 2572.2 2763.4 6.6932	270.45 2586.3 2784.4 6.7404	289.13 2633.2 2842.8 6.8673	303.51 2667.7 2887.7 6.9604	317.55 2701.3 2931.5 7.0474	331.33 2734.3 2974.6 7.1296	344.92 2767.0 3017.0 7.2078	358.36 2799.3 3065.1 7.2827