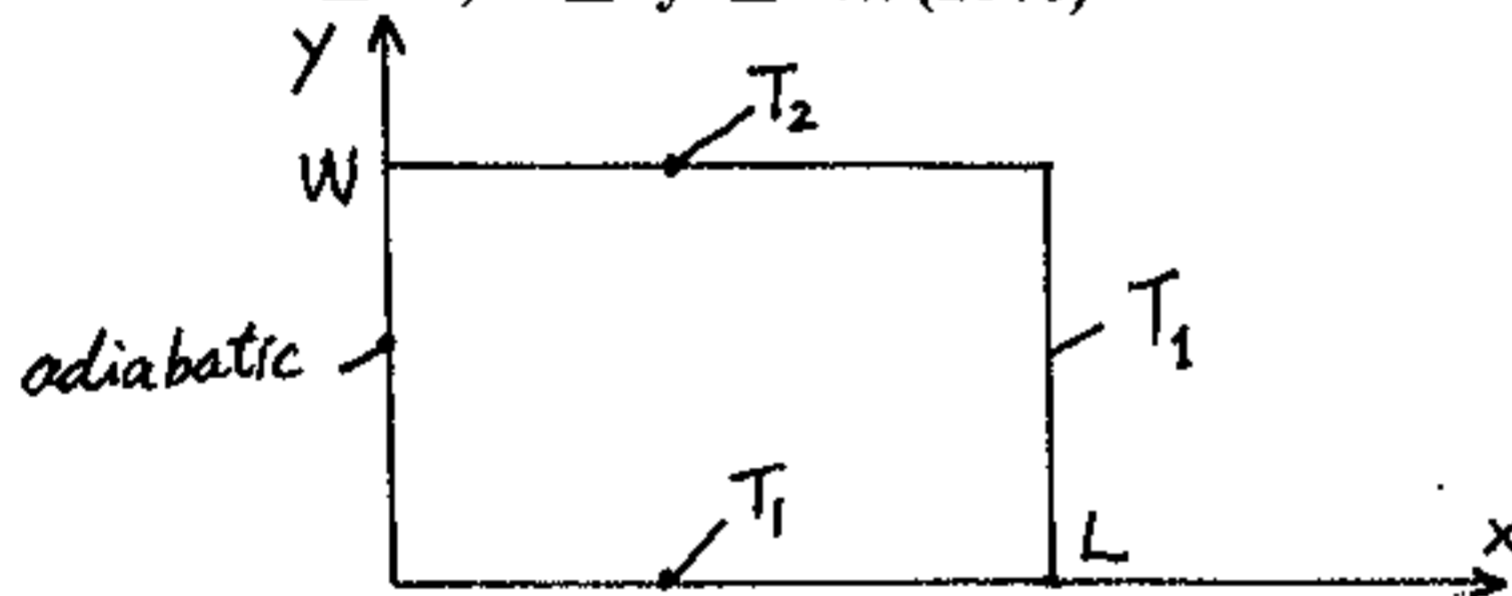


九十二學年度 工程與系統科學系(所) 乙 組碩士班研究生招生考試

科目 熱傳學 科號 3704 共 4 頁第 1 頁 \*請在試卷【答案卷】內作答

1. (a) Please describe briefly the fundamental mechanisms and basic laws of conduction, convection and thermal radiation, respectively. (15%)  
 (b) Please describe briefly the physical meanings of Biot and Prandtl numbers. (5%)
2. Please solve the following steady-state, two-dimensional conduction problem for  $0 \leq x \leq L, 0 \leq y \leq W$ . (20%)



3. Water at  $T_i$  enters, with fully developed fluid flow and thermal conditions, a circular channel heated by hot air at  $T_\infty$ . The heat transfer coefficient between water and inner wall is  $h_i$  and between hot air and outside wall is  $h_o$ . The inner and outside radii of the channel is  $r_i$  and  $r_o$ , respectively. The thermal conductivity of the channel wall is  $k$ . Determine the channel length for water to be heated to a temperature of  $T_o$ . (15%) If a fin array is to be added to enhance heat transfer, which side of the channel should be considered? Why? (5%)
4. For Problem #3, if the channel diameter is 1 cm and the water flow rate is 0.1 kg/s, the inlet and outlet temperatures are 20 and 80 °C, respectively. Determine the heat transfer coefficient  $h_i$ . (20%)  
 Hint:  $Nu = 3.66$  if the flow is laminar;  $Nu = 0.023 Re^{0.8} Pr^{0.4}$ , if the flow is turbulent.

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科目 熱傳學 科號 3704 共 4 頁第 2 頁 \*請在試卷【答案卷】內作答

5. Consider the cooling rate of a silicon wafer, fixed horizontally, after a manufacturing process. The diameter and thickness of the wafer is 300mm and 0.5 mm, respectively. The emissivity of the wafer surface is 0.65. The wafer is initially at 400 °C and is allowed to cool from both upper and lower surfaces in quiescent, ambient air and large surroundings of 20 °C. Determine the initial rate of cooling (10%) and estimate the cooling time for the wafer to reach a temperature of 50 °C.(10%) The density and specific heat for silicon are 2330 kg/m<sup>3</sup> and 712 J/kgK, respectively.

For upper surface  $Nu = 0.54 Ra^{0.25}$ ,  $10^4 \leq Ra \leq 10^7$ ;  $Nu = 0.15 Ra^{0.33}$ ,  $10^7 \leq Ra \leq 10^{11}$

For the lower surface,  $Nu = 0.27 Ra^{0.25}$ ,  $10^5 \leq Ra \leq 10^{10}$

九十二學年度 工程與系統科學系(所) 乙 組碩士班研究生招生考試

科目 熱傳學 科號 3704 共 4 頁第 3 頁 \*請在試卷【答案卷】內作答

Thermophysical Properties of Saturated Water<sup>a</sup>

Temperature, $T$ (K)	Pressure, $P$ (bars) <sup>b</sup>	Specific Volume (m <sup>3</sup> /kg)		Heat of Vaporization, $h_{fg}$ (kJ/kg)	Specific Heat (kJ/kg · K)		Viscosity (N · s/m <sup>2</sup> )		Thermal Conductivity (W/m · K)		Prandtl Number		Surface Tension, $\sigma_f \cdot 10^3$ (N/m)	Expansion Coefficient, $\beta_f \cdot 10^6$ (K <sup>-1</sup> )	Temperature, $T$ (K)
		$v_f \cdot 10^3$	$v_g$		$c_{p,f}$	$c_{p,g}$	$\mu_f \cdot 10^6$	$\mu_g \cdot 10^6$	$k_f \cdot 10^3$	$k_g \cdot 10^3$	$Pr_f$	$Pr_g$			
273.15	0.00611	1.000	206.3	2502	4.217	1.854	1750	8.02	569	18.2	12.99	0.815	75.5	-68.05	273.15
275	0.00697	1.000	181.7	2497	4.211	1.855	1652	8.09	574	18.3	12.22	0.817	75.3	-32.74	275
280	0.00990	1.000	130.4	2485	4.198	1.858	1422	8.29	582	18.6	10.26	0.825	74.8	46.04	280
285	0.01387	1.000	99.4	2473	4.189	1.861	1225	8.49	590	18.9	8.81	0.833	74.3	114.1	285
290	0.01917	1.001	69.7	2461	4.184	1.864	1080	8.69	598	19.3	7.56	0.841	73.7	174.0	290
295	0.02617	1.002	51.94	2449	4.181	1.868	959	8.89	606	19.5	6.62	0.849	72.7	227.5	295
300	0.03531	1.003	39.13	2438	4.179	1.872	855	9.09	613	19.6	5.83	0.857	71.7	276.1	300
305	0.04712	1.005	29.74	2426	4.178	1.877	769	9.29	620	20.1	5.20	0.865	70.9	320.6	305
310	0.06221	1.007	22.93	2414	4.178	1.882	695	9.49	628	20.4	4.62	0.873	70.0	361.9	310
315	0.08132	1.009	17.82	2402	4.179	1.888	631	9.69	634	20.7	4.16	0.883	69.2	400.4	315
320	0.1053	1.011	13.98	2390	4.180	1.895	577	9.89	640	21.0	3.77	0.894	68.3	436.7	320
325	0.1351	1.013	11.06	2378	4.182	1.903	528	10.09	645	21.3	3.42	0.901	67.5	471.2	325
330	0.1719	1.016	8.82	2366	4.184	1.911	489	10.29	650	21.7	3.15	0.908	66.6	504.0	330
335	0.2167	1.018	7.09	2354	4.186	1.920	453	10.49	656	22.0	2.88	0.916	65.8	535.5	335
340	0.2713	1.021	5.74	2342	4.188	1.930	420	10.69	660	22.3	2.66	0.925	64.9	566.0	340
345	0.3372	1.024	4.683	2329	4.191	1.941	389	10.89	668	22.6	2.45	0.933	64.1	595.4	345
350	0.4163	1.027	3.846	2317	4.195	1.954	365	11.09	668	23.0	2.29	0.942	63.2	624.2	350
355	0.5100	1.030	3.180	2304	4.199	1.968	343	11.29	671	23.3	2.14	0.951	62.3	652.3	355
360	0.6209	1.034	2.645	2291	4.203	1.983	324	11.49	674	23.7	2.02	0.960	61.4	697.9	360
365	0.7514	1.038	2.212	2278	4.209	1.999	306	11.69	677	24.1	1.91	0.969	60.5	707.1	365
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

國 立 清 華 大 學 命 題 紙

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科目 熱傳學 科號 3704 共 4 頁第 4 頁 \*請在試卷【答案卷】內作答

Thermophysical Properties  
of Gases at Atmospheric Pressure<sup>a</sup>

$T$ (K)	$\rho$ (kg/m <sup>3</sup> )	$c_p$ (kJ/kg · K)	$\mu \cdot 10^7$ (N · s/m <sup>2</sup> )	$\nu \cdot 10^6$ (m <sup>2</sup> /s)	$k \cdot 10^3$ (W/m · K)	$\alpha \cdot 10^6$ (m <sup>2</sup> /s)	$Pr$
<b>Air</b>							
100	3.5562	1.032	71.1	2.00	9.34	2.54	0.786
150	2.3364	1.012	103.4	4.426	13.8	5.84	0.758
200	1.7458	1.007	132.5	7.590	18.1	10.3	0.737
250	1.3947	1.006	159.6	11.44	22.3	15.9	0.720
300	1.1614	1.007	184.6	15.89	26.3	22.5	0.707
350	0.9950	1.009	208.2	20.92	30.0	29.9	0.700
400	0.8711	1.014	230.1	26.41	33.8	38.3	0.690
450	0.7740	1.021	250.7	32.39	37.3	47.2	0.686
500	0.6964	1.030	270.1	38.79	40.7	56.7	0.684
550	0.6329	1.040	288.4	45.57	43.9	66.7	0.683
600	0.5804	1.051	305.8	52.69	46.9	76.9	0.685
650	0.5356	1.063	322.5	60.21	49.7	87.3	0.690
700	0.4975	1.075	338.8	68.10	52.4	98.0	0.695
750	0.4643	1.087	354.6	76.37	54.9	109	0.702
800	0.4354	1.099	369.8	84.93	57.3	120	0.709
850	0.4097	1.110	384.3	93.80	59.6	131	0.716
900	0.3868	1.121	398.1	102.9	62.0	143	0.720
950	0.3666	1.131	411.3	112.2	64.3	155	0.723
1000	0.3482	1.141	424.4	121.9	66.7	168	0.726
1100	0.3166	1.159	449.0	141.8	71.5	195	0.728
1200	0.2902	1.175	473.0	162.9	76.3	224	0.728
1300	0.2679	1.189	496.0	185.1	82	238	0.719
1400	0.2488	1.207	530	213	91	303	0.703
1500	0.2322	1.230	557	240	100	350	0.685
1600	0.2177	1.248	584	268	106	390	0.688
1700	0.2049	1.267	611	298	113	435	0.685
1800	0.1935	1.286	637	329	120	482	0.683
1900	0.1833	1.307	663	362	128	534	0.677
2000	0.1741	1.337	689	396	137	589	0.672
2100	0.1658	1.372	715	431	147	646	0.667
2200	0.1582	1.417	740	468	160	714	0.655
2300	0.1513	1.478	766	506	175	783	0.647
2400	0.1448	1.558	792	547	196	869	0.630
2500	0.1389	1.665	818	589	222	960	0.613
3000	0.1135	2.726	955	841	486	1570	0.536