UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang Akademik 2007/2008

April 2008

IEK 206 – Operasi Unit III
[Unit Operations III]

Masa: 3 jam
[Duration: 3 hours]

Sila pastikan bahawa kertas peperiksaan ini mengandungi DUA BELAS muka surat yang bercetak sebelum anda memulakan peperiksaan ini.

Jawab LIMA soalan. Semua soalan boleh dijawab dalam Bahasa Malaysia ATAU Bahasa Inggeris.

[Please check that this examination paper consists of TWELVE pages of printed material before you begin the examination.

Answer FIVE questions. All questions can be answered either in Bahasa Malaysia OR English.]

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1. Jawab salah DUA daripada soalan-soalan di bawah:

   (a) Dengan bantuan gambarajah, huraikan mengenai lima kaedah penyuapan dalam operasi penyulingan dan bincangkan garis q bagi setiap kaedah.

   (50 markah)

   (b) Bincangkan tentang pemindahan jisim antarafasa, dan perhubungan di antara koefisien pemindahan jisim keseluruhan dengan koefisien-koefisien individu.

   (50 markah)

   (c) Satu campuran udara-wap air adalah pada 130°F dan takat embun 60°F. Dengan menggunakan carta kelembapan, carikan

   (i) kelembapan mutlak;
   (ii) kelembapan molal;
   (iii) peratusan kelembapan;
   (iv) suhu penepuan adiabatik;
   (v) kelembapan penepuan;
   (vi) haba lembab;
   (vii) isipadu lembab;
   (viii) total entalpi.

   (50 markah)

2. (a) Suatu lapisan filem larutan organik (A)- air (B) yang mempunyai ketebalan 2.05 mm pada 298 K adalah dalam sentuhan di sebelah muka dengan satu pelarut yang boleh melarutkan komponen organik tersebut tetapi tidak dapat melarutkan air. Pada lokasi 1 kepekatan bahan organik ialah 17.2 % (berat) dan ketumpatan larutan ialah 973.8 kg/m^3. Pada lokasi 2, kepekatan bahan organic menjadi 6.6 % dan ketumpatannya 987.8 kg/m^3. Keresapan organik tersebut ialah 0.81 x 10^{-9} m^2/s. Hitungkan fluks pemindahan jisim pada keadaan mantap N_A. Berat molekul bagi bahan organik itu ialah 45.5.

   $N_A = (D_{AB}/zx_{BM})(\rho/M)_{av}(x_{A1} - x_{A2})$

   $x_{BM} = (x_{B2} - x_{B1})/\ln(x_{B2}/x_{B1})$

   (50 markah)

   (b) Bincangkan mengenai spesifikasi-spesifikasi dan ciri-ciri bendalir dan alat-alatan yang diperlukan dalam rekabentuk menara penyerapan.

   (50 markah)

3. Suatu pepejal basah akan dikeringkan dari 28 hingga 10% (dasar basah) kandungan lembapan. Permukaan pengeringan ialah 1 m^2/45 kg berat kering.

   (a) Plotkan kadar pengeringan melawan kandungan lembapan bagi sistem tersebut;
   (b) Tentukan jumlah masa pengeringan.

   Data pengeringan bagi tempoh kadar-kejatuhan adalah seperti di bawah:

W	0.20	0.18	0.16	0.14	0.12	0.10	0.09	0.08	0.07	.064
10^3R	0.30	0.266	0.239	0.208	0.18	0.15	0.097	0.07	.043	.025
$(1/R)10^{-3}$	3.33	3.76	4.18	4.80	5.55	6.67	10.3	14.3	23.3	40.

$$R = -(m_s/A)\, dW/dt$$

$$\int dx/(ax + b) = (1/a) \ln (ax + b)$$

(100 markah)

4. Suatu penekan plat dan rangka yang menuraskan satu campuranlikat pepejal-cecair pada tekanan malar memberikan sejumlah 8.5 m^3 turasan selepas 1800 s dan 12 m^3 selepas 3600 s pada tamatnya proses penurasan itu. Rintangan medium turas boleh diabaikan.

   (a) Kirakan kadar penurasan akhir;
   (b) Jika 3 m^3 air digunakan untuk pembasuhan, kirakan masa pembasuhan dalam unit saat. Kadar aliran air pembasuh ialah ¼ kadar penurasan akhir.

$$dV/dt = A^2(-\Delta p)/(\mu \alpha V W)$$

(100 markah)

5. Satu turus penyulingan digunakan untuk memisah satu campuran yang mengandungi 0.30 (pecahan mol) CS_2 dan 0.7 (pecahan mol) CCl_4 untuk menghasikan satu hasil atas yang mengandungi 0.95 (pecahan mol) CS_2 dan satu hasil bawah yang mempunyai 0.06 (pecahan mol) CS_2. Nisbah refluks ialah 3.2. Suap campuran adalah pada takat gelembung. Tentukan

   (a) Jumlah bilangan plat unggul;
   (b) kedudukan plat suapan.

$$y = -qx/(1 - q) + x_F/(1 - q)$$

$$y_{n+1} = R_D x_n/(R_D + 1) + x_D/(R_D + 1)$$

Data:

Peratus mol CS_2 di dalam wap:

0 8.23 15.55 26.6 33.2 49.5 63.4 74.7 82.9 87.8 93.2 1.0

Peratus mol CS_2 di dalam cecair:

0 2.96 6.15 11.06 14.35 25.85 39.0 53.2 66.3 75.8 86.1 1.0

(100 markah)

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6. Suatu turus penyulingan direkabentukkan untuk memisah 0.2 kg/s suatu campuran yang mengandungi 0.54 (pecahan mol) benzena dan 0.46 (pecahan mol) toluena untuk menghasilkan hasil atas yang berkepekatan 0.97 (pecahan mol) benzena dan hasil bawah yang berkepekatan 0.98 (pecahan mol) toluena. Nisbah refluks ialah 2 kali nisbah refluks minimum. Suap adalah pada takat gelembung. Tentukan

(a) nisbah refluks minimum;
(b) jumlah bilangan plat unggul;
(c) kedudukan plat suapan.

Data:
Pecahan mol benzena di dalam wap:
0 0.04 0.26 0.46 0.63 0.77 0.9 1.0
Pecahan mol benzena di dalam cecair:
0 0.02 0.13 0.26 0.41 0.58 0.78 1.0

(100 markah)

1. *Answer any TWO of the following:*

   (a) *With the help of diagrams, describe the five conditions in which a feed mixture is introduced into a distillation column, and discuss the q line for each condition.*

   (50 marks)

   (b) *Discuss the interphase mass transfer, and the relationship between the overall mass transfer coefficients and the individual coefficients.*

   (50 marks)

   (c) *A water vapor (A)-air (B) mixture is at 130°F and a dew point of 60°F. Using humidity chart, determine*

   (i) *absolute humidity;*
   (ii) *molal humidity;*
   (iii) *percentage humidity;*
   (iv) *adiabatic saturation temperature;*
   (v) *saturation humidity;*
   (vi) *humid heat;*
   (vii) *humid volume;*
   (viii) *total enthalpy.*

   (50 marks)

2. (a) *An organic (A)- water (B) solution film 2.05 mm thick at 298 K is in contact at one surface with a solvent in which the organic liquid is soluble and water is not. At point 1 the organic concentration is 17.2% (weight) and the solution density is 973.8 kg/m^3. At point 2 the organic concentration is 6.6 % and its density 987.8 kg/m^3. The diffusivity of the organic is 0.81 x 10^{-9} m^2/s. Calculate the steady-state flux N_A. The molecular weight of the organic is 45.5.*

$$N_A = (D_{AB}/zx_{BM})(\rho/M)_{av}(x_{A1} - x_{A2})$$
$$x_{BM} = (x_{B2} - x_{B1})/ln(x_{B2}/x_{B1})$$

   (50 marks)

   (b) *Discuss about the specifications, and the characteristics of the fluid and of the equipment needed in the design of an absorption tower.*

   (50 marks)

3. *A wet solid is to be dried from 28 to 10 % (wet basis) moisture content. The drying surface is 1 m^2/45 kg dry weight.*

   (a) Plot rate of drying versus moisture content for this system;
   (b) Determine the total drying time.

   The falling-rate period drying data are as follows:

W	0.20	0.18	0.16	0.14	0.12	0.10	0.09	0.08	0.07	.064
10^3R	0.30	0.266	0.239	0.208	0.18	0.15	0.097	0.07	.043	.025
$(1/R)10^{-3}$	3.33	3.76	4.18	4.80	5.55	6.67	10.3	14.3	23.3	40.

$$R = - (m_s/A)\, dW/dt$$

$$\int dx/(ax + b) = (1/a)\, \ln (ax + b)$$

(100 marks)

4. *A plate and frame filter press, filtering a slurry at constant pressure, gave a total of 8.5 m^3 of filtrate in 1800 s and 12 m^3 in 3600 s, when filtration was stopped. The resistance of the cloth can be neglected.*

   (a) Calculate the final rate of filtration;
   (b) If 3 m^3 of water are used for washing, calculate the washing time, in second. The rate of washing water is ¼ of final filtration rate.

$$dV/dt = A^2(-\Delta p)/(\mu \alpha V W)$$

(100 marks)

5. *A distillation column is used to separate a mixture containing 0.30 (mole fraction) of CS_2 and 0.7 (mole fraction) of CCl_4 into an overhead product containing 0.95 (mole fraction) of CS_2 and a bottom product containing 0.06 (mole fraction) of CS_2. The reflux ratio is 3.2. The feed mixture enters the column at its bubble point. Determine*

   (a) the total number of ideal plates;
   (b) the position of the feed plate.

$$y = - qx/(1 - q) + x_F/(1 - q)$$
$$y_{n+1} = R_D x_n/(R_D + 1) + x_D/(R_D + 1)$$

Data:
Mole percent of CS_2 in vapor:

0	8.23	15.55	26.6	33.2	49.5	63.4	74.7	82.9	87.8	93.2	100.0

Mole percent of CS_2 in liquid:

0	2.96	6.15	11.06	14.35	25.85	39.0	53.2	66.3	75.8	86.1	100.0

(100 marks)

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6. *A distillation column is to be designed to separate 0.2 kg/s of a mixture of 0.54 (mole fraction) of benzene and 0.46 of toluene into an overhead product of 0.97 mole fraction of benzene and a bottom product of 0.98 mole fraction of toluene at twice the minimum reflux ratio. The feed is at its bubble point.*

Determine

(a) the minimum reflux ratio;
(b) the total number of ideal plates;
(c) the position of the feed plate.

Data:
Mole fraction of benzene in vapor:
0 0.04 0.26 0.46 0.63 0.77 0.9 1.0
Mole fraction of benzene in liquid:
0 0.02 0.13 0.26 0.41 0.58 0.78 1.0

(100 marks)

VALUES OF GAS CONSTANT

Temperature	Mass	Energy	*R*
Kelvins	kg mol	J	8314.47
		cal_{IT}	1.9859×10^{3}
		cal	1.9873×10^{3}
		m^3-atm	82.056×10^{-3}
	g mol	cm^3-atm	82.056
Degrees Rankine	lb mol	Btu	1.9858
		$ft\text{-}lb_f$	1545.3
		Hp-h	7.8045×10^{-4}
		kWh	5.8198×10^{-4}

CONVERSION FACTORS AND CONSTANTS OF NATURE

To convert from	To	Multiply by†
acre	ft^2	43,560*
	m^2	4046.85
atm	N/m^2	$1.01325* \times 10^{5}$
	$lb_f/in.^2$	14.696
Avogadro number	particles/g mol	6.022169×10^{23}
barrel (petroleum)	ft^3	5.6146
	gal (U.S.)	42*
	m^3	0.15899
bar	N/m^2	$1* \times 10^{5}$
	$lb_f/in.^2$	14.504
Boltzmann constant	J/K	1.380622×10^{-23}
Btu	cal_{IT}	251.996
	$ft\text{-}lb_f$	778.17
	J	1055.06
	kWh	2.9307×10^{-4}
Btu/lb	cal_{IT}/g	0.55556
Btu/lb-°F	cal_{IT}/g-°C	1*
Btu/ft^2-h	W/m^2	3.1546
Btu/ft^2-h-°F	W/m^2-°C	5.6783
	$kcal/m^2$-h-K	4.882
Btu-ft/ft^2-h-°F	W-m/m^2-°C	1.73073
	kcal/m-h-K	1.488

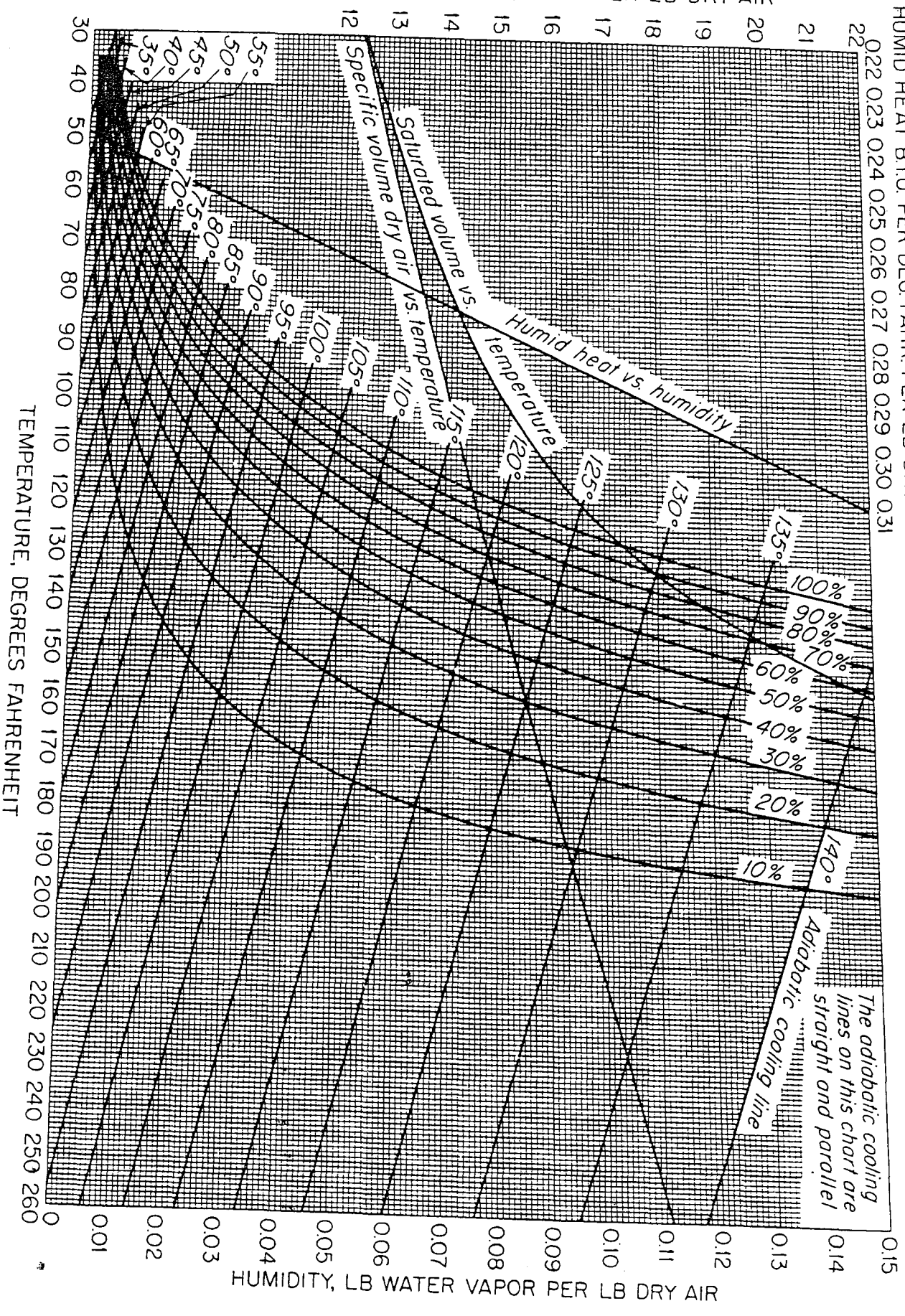
(Continued)

To convert from	To	Multiply by†
cal_{IT}	Btu	3.9683×10^{-3}
	ft-lb_f	3.0873
	J	4.1868*
cal	J	4.184*
cm	in.	0.39370
	ft	0.0328084
cm^3	ft^3	3.531467×10^{-5}
	gal (U.S)	2.64172×10^{-4}
cP (centipoise)	kg/m-s	$1* \times 10^{-3}$
	lb/ft-h	2.4191
	lb/ft-s	6.7197×10^{-4}
cSt (centistoke)	m^2/s	$1* \times 10^{-6}$
faraday	C/g mol	9.648670×10^4
ft	m	0.3048*
ft-lb_f	Btu	1.2851×10^{-3}
	cal_{IT}	0.32383
	J	1.35582
ft-lb_f/s	Btu/h	4.6262
	hp	1.81818×10^{-3}
ft^2/h	m^2/s	2.581×10^{-5}
	cm^2/s	0.2581
ft^3	cm^3	2.8316839×10^4
	gal (U.S.)	7.48052
	L	28.31684
ft^3-atm	Btu	2.71948
	cal_{IT}	685.29
	J	2.8692×10^3
ft^3/s	gal (U.S)/min	448.83
gal (U.S.)	ft^3	0.13368
	$in.^3$	231*
gravitational constant	$N\text{-}m^2/kg^2$	6.673×10^{-11}
gravity acceleration, standard	m/s^2	9.80665*
h	min	60*
	s	3600*
hp	Btu/h	2544.43
	kW	0.74624
hp/1000 gal	kW/m^3	0.197
in.	cm	2.54*
$in.^3$	cm^3	16.3871
J	erg	$1* \times 10^7$
	ft-lb_f	0.73756
kg	lb	2.20462
kWh	Btu	3412.1
L	m^3	$1* \times 10^{-3}$
lb	kg	0.45359237*
lb/ft^3	kg/m^3	16.018
	g/cm^3	0.016018
$lb_f/in.^2$	N/m^2	6.89473×10^3
lb mol/ft^2-h	kg mol/m^2-s	1.3562×10^{-3}
	g mol/cm^2-s	1.3562×10^{-4}
light, speed of	m/s	2.997925×10^8

(Continued)

To convert from	To	Multiply by†
m	ft	3.280840
	in.	39.3701
m^3	ft^3	35.3147
	gal (U.S.)	264.17
N	dyn	$1* \times 10^5$
	lb_f	0.22481
N/m^2	$lb_f/in.^2$	1.4498×10^{-4}
Planck constant	J-s	6.626196×10^{-34}
proof (U.S.)	percent alcohol by volume	0.5
ton (long)	kg	1016
	lb	2240*
ton (short)	lb	2000*
ton (metric)	kg	1000*
	lb	2204.6
yd	ft	3*
	m	0.9144*

† Values that end in an asterisk are exact, by definition.


VOLUME, CU FT. PER LB DRY AIR
12 13 14 15 16 17 18 19 20 21 22
HUMID HEAT B.T.U. PER DEG. FAHR. PER LB DRY AIR
0.22 0.23 0.24 0.25 0.26 0.27 0.28 0.29 0.30 0.31
Specific volume dry air vs. temperature
Saturated volume vs. temperature
Humid heat vs. humidity
Adiabatic cooling line
The adiabatic cooling lines on this chart are straight and parallel
55° 50° 45° 40° 35° 60° 65° 70° 75° 80° 85° 90° 95° 100° 105° 110° 115° 120° 125° 130° 135° 140°
100% 90% 80% 70% 60% 50% 40% 30% 20% 10%
30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260
TEMPERATURE, DEGREES FAHRENHEIT
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.10 0.11 0.12 0.13 0.14 0.15
HUMIDITY, LB WATER VAPOR PER LB DRY AIR

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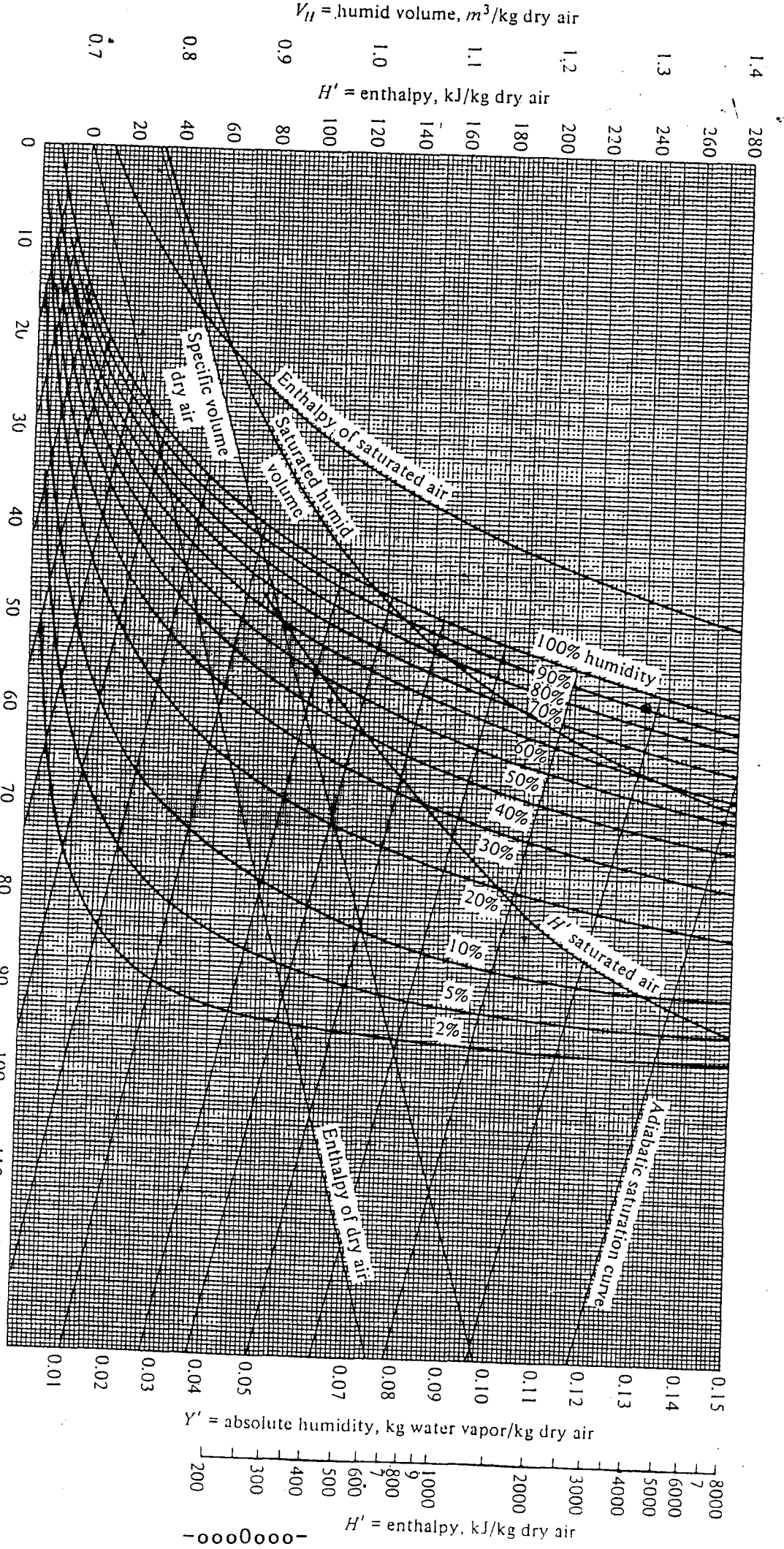

Figure Psychrometric chart for air-water vapor, 1 std atm abs, in SI units.

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