UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2008/2009

November 2008

EKC 214 – Energy Balance
[Imbangan Tenaga]

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of <u>TEN</u> pages of printed material and <u>TWO</u> pages of Appendix before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi <u>SEPULUH</u> muka surat yang bercetak dan <u>DUA</u> muka surat Lampiran sebelum anda memulakan peperiksaan ini.]

<u>Instructions</u>: Answer **FOUR** (4) questions. Answer **<u>TWO</u>** (2) questions from Section A. Answer questions No. 4 is **<u>COMPULSORY</u>** and any **<u>ONE</u>** (1) question from Section B.

*[**<u>Arahan</u>:** Jawab **EMPAT** (4) soalan. Jawab **<u>DUA</u>** (2) soalan dari Bahagian A. Jawab soalan No. 4 yang **<u>DIWAJIBKAN</u>** dan mana-mana **<u>SATU</u>** (1) soalan lain dari Bahagian B.]*

You may answer the question either in Bahasa Malaysia or in English.

[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

<u>Section A</u> : Answer any <u>TWO</u> questions.
<u>Bahagian A</u> : Jawab mana-mana <u>DUA</u> soalan.

1. [a] Are the following variables intensive or extensive?

Adakah pembolehubah-pembolehubah yang berikut intensif atau ekstensif?

[i] Partial pressure
Tekanan separa

[ii] Relative saturation
Ketepuan relatif

[iii] Specific volume
Isipadu tentu

[iv] Potential energy
Tenaga keupayaan

[v] Volume
Isipadu

[5 marks/markah]

[b] You are doing your industrial training in a petroleum refinery. The refinery has a small power plant that generates electricity by expanding waste process steam in a turbine. Your supervisor asked you to study the turbine to determine if it is operating as efficiently as possible. One way to ensure good efficiency is to have the turbine operate adiabatically. Measurements show that for steam at 300°C and 20 bar, the work output of the turbine is 86.5 hp, the rate of steam consumption is 500 kg/h and the steam leaves the turbine at 1 bar and consists of 15% moisture (i.e. liquid H_2O).

Anda sedang menjalani latihan industri anda di sebuah kilang penapisan petroleum. Kilang tersebut menghasilkan beberapa loji kuasa kecil yang menjana elektrik melalui pengembangan stim proses buangan dalam sebuah turbin. Penyelia anda meminta anda mengkaji turbin tersebut untuk menentukan sama ada ia sedang beroperasi secekap mungkin. Satu cara untuk memastikan kecekapan yang baik adalah turbin tersebut beroperasi secara adiabatik. Pengukuran menunjukkan bahawa stim pada 300°C dan 20 bar akan menghasilkan turbin sebanyak 86.5 kuasa kuda, kadar penggunaan stim sebanyak 500 kg/j dan stim tersebut meninggalkan turbin pada 1 bar serta mengandungi 15% kelembapan (iaitu H_2O cecair).

[i] Draw a schematic diagram of the process.
Lukiskan gambarajah berskema bagi proses tersebut.

[2 marks/markah]

[ii] Is the turbine operating adiabatically? Support your answer with calculations.
Adakah turbin tersebut beroperasi secara adiabatik? Sokong jawapan anda dengan pengiraan.

[7 marks/markah]

[c] A stream of warm air with a dry-bulb temperature of 40°C and a wet-bulb temperature of 32°C is mixed adiabatically with a stream of saturated cool air at 18°C. The dry mass flow rates of the warm and cool air stream are 8 and 6 kg/s, respectively. Assume a total pressure of 1 atm.

Suatu aliran udara suam dengan suhu bebuli kering 40°C dan suhu bebuli basah 32°C dicampur secara adiabatik dengan suatu aliran udara dingin tepu pada 18°C. Kadar aliran jisim kering bagi aliran udara suam dan dingin masing-masing ialah 8 dan 6 kg/s. Dengan mengandaikan jumlah tekanan sebanyak 1 atm,

[i] Draw a schematic diagram of the process.
Lukiskan gambarajah berskema bagi proses itu.

[2 marks/markah]

[ii] Determine the temperature of the mixture
Tentukan suhu campuran

[3 marks/markah]

[iii] Determine the enthalpy of the mixture.
Tentukan entalpi campuran

[3 marks/markah]

[iv] Determine the relative humidity of the mixture.
Tentukan kelembapan relatif campuran.

Please show the answers on the humadity chart and submit along with your answer. (State your assumptions)

Sila tunjukkan jawapan anda pada carta kelembapan dan hantarkan carta tersebut bersama-sama jawapan anda. (Nyatakan andaian-andaian yang telah dibuat).

[3 marks/markah]

2. [a] Under what conditions are the dry bulb, wet bulb, and dew point temperature equal?
Dalam keadaan-keadaan manakah, suhu bebuli kering, bebuli basah dan titik embun menjadi sama?

[3 marks/markah]

[b] What is the difference between heat and internal energy?
Apakah perbezaan antara haba dan tenaga dalaman?

[3 marks/markah]

[c] A turbine driven by water flowing from a reservoir 80 m higher than the turbine, delivers 200 kW. The friction losses in the system yield an overall efficiency (actual work/ideal reversible work) of 75%. The reservoir is open to the atmosphere, and the exit velocity of the water is 5 m/s at a pressure of 150 kPa from the turbine.

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Sebuah turbin yang digerakkan oleh air yang mengalir dari sebuah takungan 80 m lebih tinggi dari turbin tersebut menghasilkan 200 kW. Kehilangan geseran dalam sistem menghasilkan kecekapan keseluruhan (kerja sebenar/kerja berbalik unggul) sebanyak 75%. Takungan tersebut adalah terbuka kepada atmosfera dan halaju keluar air ialah 5 m/s pada tekanan 150 kPa dari turbin.

[i] Draw a schematic diagram of the process.
Lukiskan gambarajah berskema bagi proses itu.

[2 marks/markah]

[ii] Calculate the flow rate of the water in kg/s.
Kirakan kadar aliran air dalam kg/s.

[10 marks/markah]

[d] Consider the following systems:
Pertimbangkan sistem-sistem yang berikut:

[i] Open system, steady state
Sistem terbuka, keadaan mantap

[ii] Open system, unsteady state
Sistem terbuka, keadaan tak mantap

[iii] Closed system, steady state
Sistem tertutup, keadaan mantap

[iv] Closed system, unsteady state
Sistem tertutup, keadaan tak mantap

For which system(s) can energy cross the system boundary?
Dalam sistem manakah tenaga boleh merentasi sempadan sistem?

[4 marks/markah]

[e] What is the difference between the constant enthalpy and constant wet bulb temperature lines on the humidity chart?
Apakah perbezaan antara garisan entalpi malar dan garisan suhu bebuli basah malar dalam carta kelembapan?

[3 marks/markah]

3. [a] Answer the following questions **true** or **false**:
*Jawab soalan-soalan berikut **benar** atau **palsu**:*

[i] The work done by a constant volume system is always zero.
Kerja yang dilakukan oleh suatu sistem isipadu malar akan sentiasa sifar.

[ii] Heat is a measure of the temperature of a system.
Haba ialah suatu ukuran bagi suhu suatu sistem

[iii] In a process in which a pure substance starts at a specified temperature and pressure, goes through several temperature and pressure changes, and then returns to the initial state, $\Delta U = 0$.
Dalam suatu proses di mana suatu bahan bermula pada suhu dan tekanan tertentu dan melalui beberapa perubahan suhu dan tekanan dan kemudiannya kembali kepda keadaan awal $\Delta U = 0$.

[iv] The units of the heat capacity can be (cal)/(g)(^oC) or Btu/(lb)(^oF), and the numerical value of the heat capacity is the same in each system of units.
Unit-unit bagi muatan haba ialah kal/g ^oC atau Btu/lb ^oF dan nilai berangka muatan haba adalah sama bagi setiap sistem unit.

[v] The heat of vaporization depends on temperature.
Haba pengewapan bergantung kepada suhu.

[vi] Heat of condensation is the negative of the heat of vaporization.
Haba pemeluwapan adalah negatif kepada haba pengewapan.

[6 marks/markah]

[b] An insulated tank contains 500 kg of a solution of 20% sulfuric acid (H_2SO_4) at 340 K. 300 kg of a 96% solution of H_2SO_4 at 310 K is added to this solution. To heat the solution, 100 kg of superheated steam is introduced at 1 atm and 400 K.

Sebuah tangki tertebat mengandungi 500 kg larutan asid sulfurik 20% (H_2SO_4) pada 340 K. 300 kg larutan 96% H_2SO_4 pada 310 K ditambah kepada larutan di atas. Untuk memanaskan larutan, 100 kg stim panas lampau diperkenalkan pada 1 atm dan 400 K.

[i] What is the final temperature of the solution?
Apakah suhu akhir larutan tersebut?

[6 marks/markah]

[ii] What are the concentration of H_2SO_4 and water in the final solution?
Apakah kepekatan H_2SO_4 dan air dalam larutan akhir?

[6 marks/markah]

[c] List four adiabatic cooling processes.
Senaraikan empat proses pendinginan adiabatik

[2 marks/markah]

[d] Explain the difference between latent heat and sensible heat and compare their relative magnitudes.
Terangkan perbezaan antara haba pendam dan haba deria serta bandingkan magnitud relatif mereka.

[5 marks/markah]

Section B : Answer Question 4 which is COMPULSORY and ONE other question.
Bahagian B : Jawab Soalan No. 4 yang DIWAJIBKAN dan mana-mana SATU soalan lain.

4. Ethylbenzene is converted to styrene in the catalytic dehydrogenation reaction

$$C_8H_{10}(g) \rightarrow C_8H_8(g) + H_2: \ \Delta\hat{H}_r^\circ\ (600^\circ C) = +124.5 \text{ kJ/mol}$$

Fresh and recycled liquid ethylbenzene are combined and heated from 25°C to 500°C and the heated ethylbenzene is mixed adiabatically with steam at 700°C to produce the feed to the reactor at 600°C. (The steam suppresses undesired side reactions and removes carbon deposited on the catalyst surface). A once through conversion of 35% is achieved in the reactor and the products emerge at 560°C. The product stream is cooled to 25°C, condensing essentially all of the water, ethylbenzene and styrene and allowing hydrogen to pass out as a recoverable by-product of the process. The water and hydrocarbon liquids are immiscible and are separated in a settling tank decanter. The water is vaporized and heated to produce the steam that mixes with the ethylbenzene feed to the reactor. The hydrocarbon stream leaving the decanter is fed to a distillation tower (actually, a series of towers), which separates the mixture into essentially pure styrene and ethylbenzene, each at 25°C after cooling and condensation steps have been carried out. The ethylbenzene is recycled to the reactor preheater and the styrene is taken off as a product.

Etilbenzena ditukarkan ke stirena dalam reaksi penyahhidrogenan bermagkin

$$C_8H_{10}(g) \rightarrow C_8H_8(g) + H_2: \ \Delta\hat{H}_r^\circ\ (600^\circ C) = +124.5 \text{ kJ/mol}$$

Aliran segar dan kitaran semula etilbenzena digabungkan dan kemudian dipanaskan dari 25°C ke 500°C. Etilbenzena panas dicampurkan secara adiabatik dengan stim pada suhu 700°C dimana ia disuap ke reaktor bersuhu 600°C. (Stim menahan tindakbalas sampingan yang tidak diperlukan. Ia juga berupaya menyingkirkan karbon yang terbentuk pada permukaan mangkin). Penukaran sekali lalu dalam reaktor dicapai pada 35% dan produk-produk darinya keluar pada suhu 560°C. Aliran produk itu disejukkan ke 25°C, di mana kesemua air, etilbenzena dan stirena dipeluwap. Hidrogen dikeluarkan sebagai produk sampingan proses tersebut yang boleh dipulihkan. Air dan cecair hidrokarbon tidak bercampur dan dipisahkan menggunakan tangki enapan penyiring. Air itu diwapkan dan dipanaskan menjadi stim yang akan dicampur dengan suapan etilbenzena. Aliran hidrokarbon yang keluar dari penyiring kemudiannya disuapkan ke menara penyulingan (sebenarnya, menara berturutan) di mana campuran tersebut akan dipisahkan ke stirena tulen dan etilbenzena. Aliran stirena dan etilbenzena adalah pada suhu 25°C selepas langkah-langkah pemeluwapan dilakukan. Etilbenzena dikitar semula ke reaktor prapemanas dan stirena diambil sebagai produk.

[a] Draw a schematic flow sheet of the process.
Lukiskan aliran berskema proses tersebut.

[5 marks/markah]

[b] Calculate the required fresh ethylbenzene feed rate, the flow rate of recycled ethylbenzene and the circulation rate of water, all in mol/h (assume P = 1 atm) on the basis of 100 kg/h styrene produced.

Kirakan keperluan kadar aliran segar etilbenzena, kadar aliran kitaran semula etilbenzena dan kadar edaran air dalam unit mol/j dengan asas 100 kg/j stirena dihasilkan (anggapkan P = 1 atm).

[10 marks/markah]

[c] Calculate the required rates of heat input or withdrawal in kJ/h for ethylbenzene preheater and reactor.
Kirakan kadar haba yang dimasukkan atau dikeluarkan dalam kJ/j untuk pra-pemanas etilbenzena dan reaktor.

[6 marks/markah]

[d] Suggest possible ways to improve the energy economy of this process.
Cadangkan cara-cara yang mungkin untuk membaiki ekonomi tenaga proses tersebut.

[4 marks/markah]

Physical Property Data:
Data sifat fizikal:

Ethylbenzene : $(C_p)_{liquid} = 182$ J/ (mol·°C)
$(\Delta\hat{H}_v) = 36.0$ kJ/mol at 136°C
$(C_p)_{vapor}$ [J/ (mol·°C)] = 118 + 0.30T(°C)

Etilbenzena : $(C_p)_{cecair} = 182$ *J/ (mol·°C)*
$(\Delta\hat{H}_v) = 36.0$ *kJ/mol pada 136°C*
$(C_p)_{wap}$ *[J/ (mol·°C)] = 118 + 0.30T(°C)*

Styrene: $(C_p)_{liquid} = 209$ J/ (mol·°C)
$(\Delta\hat{H}_v) = 37.1$ kJ/mol at 145°C
$(C_p)_{vapor}$ [J/ (mol·°C)] = 115 + 0.27T(°C)

Stirena : $(C_p)_{cecair} = 209$ *J/ (mol·°C)*
$(\Delta\hat{H}_v) = 37.1$ *kJ/mol pada 145°C*
$(C_p)_{wap}$ *[J/ (mol·°C)] = 115 + 0.27T(°C)*

5. [a] What is adiabatic flame temperature?
Apakah suhu nyalaan adiabatik?

[2 marks/markah]

[b] Define ignition temperature.
Takrifkan suhu pencucuhan.

[2 marks/markah]

[c] Define flash point of a liquid.
Takrifkan titik kilat cecair.

[2 marks/markah]

[d] What is a flame?
Apakah nyalaan?

[2 marks/markah]

[e] What is detonation?
Apakah ledakan?

[2 marks/markah]

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[f] The standard heat of reaction for the combustion of liquid n-nonane (C_9H_{20}) to form CO_2 and liquid water at 25°C and 1 atm is $\Delta\hat{H}^\circ_r = -6124$ kJ/mol. Briefly explain what that means. Is the reaction exothermic or endothermic at 25°C? Would you have to heat or cool the reactor to keep the temperature constant? What would temperature be if the reactor run adiabatically? What can you infer about the energy required to break the molecular bonds of the reactants and that released when the products bonds form?

Haba piawai tindakbalas bagi pembakaran cecair n-nonana (C_9H_{20}) untuk membentuk CO_2 dan air pada 25°C dan 1 atm adalah $\Delta\hat{H}^\circ_r = -6124$ kJ/mol. Terangkan secara ringkas maksud penyataan tersebut. Adakah tindakbalas tersebut eksotermik atau endotermik pada 25°C? Adakah perlu anda panaskan atau sejukkan bagi mengekalkan reaktor pada suhu malar? Apakah suhu yang sepatutnya jika reaktor beroperasi secra adiabatik? Apakah telahan yang anda boleh katakan mengenai tenaga yang diperlukan untuk memecahkan ikatan molekul bahan tindakbalas dan tenaga yang dilepaskan semasa ikatan molekul terbentuk?

[10 marks/markah]

[g] Arrange the following steps in the correct sequence for calculating energy balance on a reactive system.
Susun turutan prosedur umum bagi pengiraan keseimbangan tenaga sistem bertindakbalas.

[i] Choose reference states for specific enthalpy calculation.
Pilih keadaan rujukan untuk pengiraan entalpi tentu.

[ii] Calculate each unknown stream component enthalpy for the species going from its reference state to the process state and insert the enthalpies in the table.
Kirakan enthalpi komponen yang tidak diketahui untuk setiap spesis dari keadaan rujukan ke keadaan proses. Isikan nilai-nilai entalpi dalam jadual.

[iii] Calculate the change of enthalpy, $\Delta\dot{H}$ for the reactor.
Kirakan perubahan entalpi, $\Delta\dot{H}$ untuk reaktor.

[iv] Complete the material balance calculations on the reactor.
Lengkapkan pengiraan imbangan jisim pada reaktor.

[v] For a single reaction in a continuous process, calculate the extent of reaction.
Untuk tindakbalas tunggal dalam proses berterusan, kirakan darjah tindakbalas.

[vi] Substitute the calculated value of $\Delta\dot{H}$ in the energy balance and complete the required calculations.
Gantikan nilai $\Delta\dot{H}$ yang dikira dalam imbangan tenaga dan lengkapkan pengiraan yang dikehendaki.

[vii] **Prepare the inlet-outlet enthalpy table, by inserting known molar amount or flow rates for all inlet and outlet stream components.**
Sediakan jadual entalpi keluar masuk dengan memasukkan jumlah molar yang diketahui ataupun kadar aliran keluar masuk komponen-komponen aliran.

[5 marks/markah]

6. [a] 90 kg of sodium nitrate is dissolved in 110 kg of water. When the dissolution is complete (at time t = 0), pure water is fed to the tank at a constant rate $\dot{m}$ (kg/min), and solution is withdrawn from the tank at the same rate. The tank may be considered perfectly mixed.

90 kg natrium nitrat dilarutkan dalam 110 kg air. Apabila pelarutan telah lengkap (pada masa t = 0), air tulen disuap ke dalam tangki pada kadar malar, $\dot{m}$ (kg/min), dan larutan itu juga dikeluarkan dari tangki pada kadar yang sama. Tangki tersebut dianggap dalam keadaan teraduk sempurna.

[i] Write a total mass balance on the tank and use it to prove that the total mass of liquid in the tank remains constant at its initial value.
Tuliskan imbangan bagi jisim tangki tersebut dan gunakan ia untuk membuktikan jumlah jisim cecair dalam tangki tersebut adalah malar pada nilai awalan.

[3 marks/markah]

[ii] Write a balance on sodium nitrate, letting x (t, $\dot{m}$) equal the mass fraction of $NaNO_3$ in the tank and outlet stream. Convert the balance into an equation for dx/dt and provide an initial condition.
Tuliskan imbangan natrium bagi nitrat, biarkan x (t, $\dot{m}$) bersamaan pecahan jisim $NaNO_3$ dalam tangki dan aliran keluar. Tukarkan imbangan tersebut ke persamaan dx/dt dan kekalkan keadaan awal.

[3 marks/markah]

[iii] Refer Figure Q. 6., data for $\dot{m}$ = 50 kg/min, 100 kg/min and 200 kg/min are plotted. Discuss the results shown in the figure in light of part [ii].

Rujuk pada Gambarajah S.6., data-data bagi 50 kg/min, 100 kg/min dan 200 kg/min telah dilakarkan. Bincangkan keputusan yang ditunjukkan dalam gambarajah dengan merujuk pada bahagian (ii).

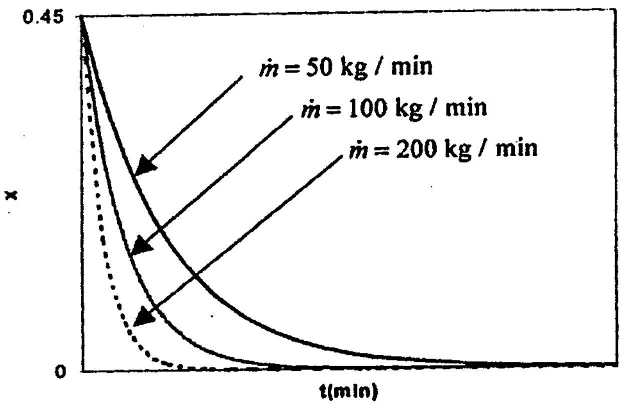

Figure Q.6.
Gambarajah S.6.

[3 marks/markah]

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[iv] Generate a plot using the general balance equations obtained in part [ii] for 50 kg/min. Evaluate the quality of equations in terms of standard error. You are given a set experimental data for comparison. [Refer to Table Q.6.].

Janakan plot dengan menggunakan persamaan imbangan umum yang didapati dalam bahagian (ii) untuk 50 kg/min. Nilaikan kualiti persamaan tersebut dari segi ralat piawai. Anda diberi satu set data eksperimen untuk perbandingan. [Rujuk Jadual S.6.].

Table Q.6.
Jadual S.6.

Conversion,x *Penukaran,x*	0.270	0.170	0.100	0.060	0.040	0.020	0.010	0.008	0.005	0.003
Time, t *Masa, t(min)*	2	4	6	8	10	12	14	16	18	20

[4 marks/markah]

[b] The ethanol dehydrogenation reaction is carried out with the feed entering at 300°C. The feed contains 85 mole % and the balance acetaldehyde and enters the reactor at a rate of 125 mol/s. To keep the temperature from dropping too much and thereby decreasing the reaction rate to an unacceptably low level, heat is transferred to the reactor. When the heat addition rate is 2440 kW, the outlet temperature is 253°C, calculate the fractional conversion of ethanol achieved in the reactor.

Tindakbalas penyahhidrogenan etanol dilakukan dengan suapan pada 300°C. Suapan mengandungi 85 mol % dan bakinya adalah asetaldehid. Suapan memasuki reaktor pada kadar 125 mol/s. Bagi mengekalkan suhu agar tidak menurun terlalu banyak dan kadar tindakbalas menurun ke peringkat yang rendah tahapnya, haba dipindahkan ke reaktor. Jika kadar tambahan haba adalah 2440 kW dan suhu keluar adalah 253°C, kirakan pecahan penukaran etanol yang dicapai dalam reaktor itu.

[12 marks/markah]

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Appendix
Lampiran

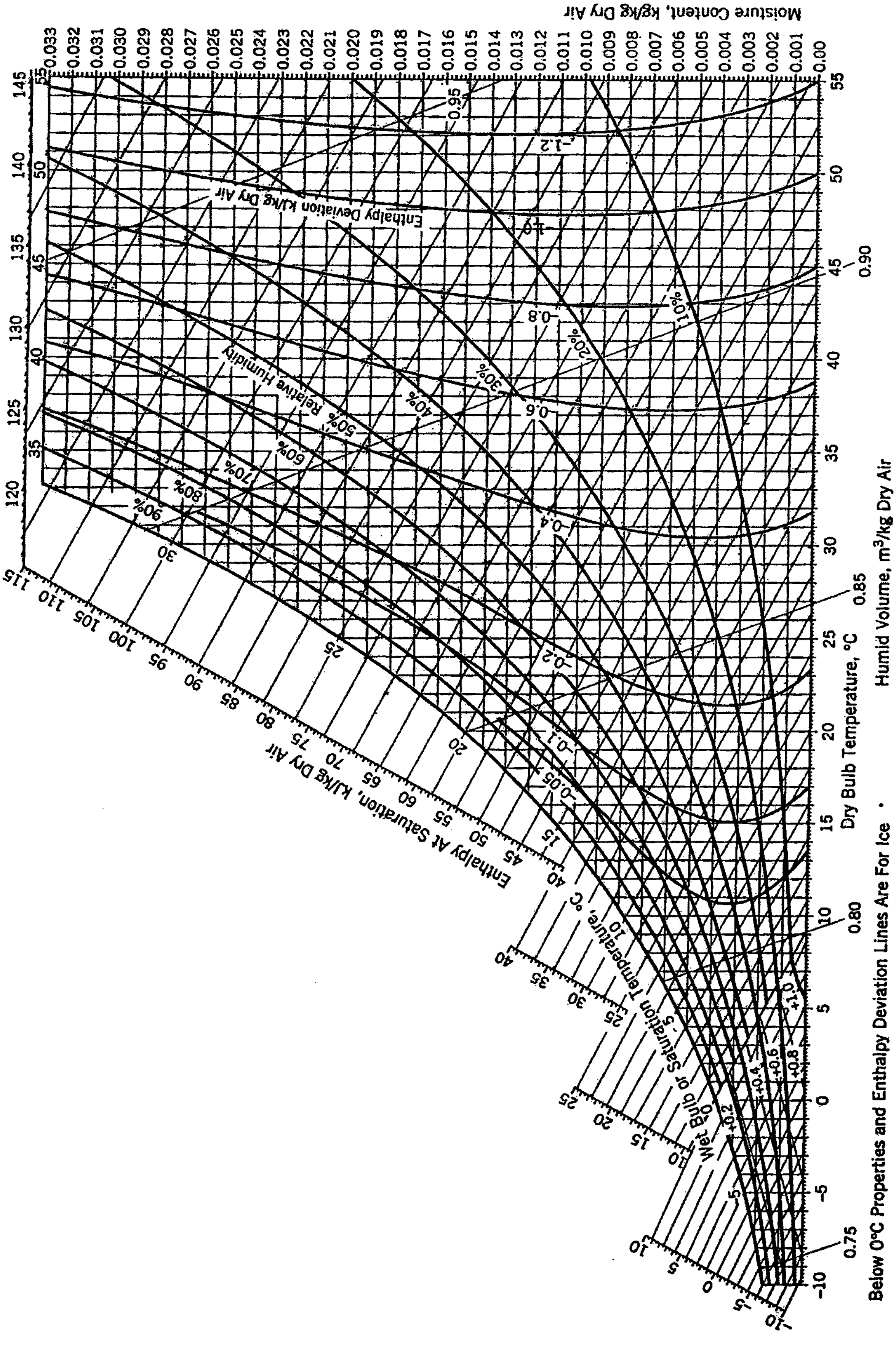

Figure Psychrometric chart—SI units. Reference states: H_2O (L, 0°C, 1 atm), dry air (0°C, 1 atm). (Reprinted with permission of Carrier Corporation.)

Physical Property Table

Compound	Mol Wt	S.G	T_m(°C)	$\Delta\hat{H}_m$ (T_m) kJ/mol	T_b(°C)	$\Delta\hat{H}_v$ (T_b) kJ/mol	T_c (K)	P_c (atm)	($\Delta\hat{H}_f^o$) kJ/mol	($\Delta\hat{H}_c^o$) kJ/mol
Acetaldehyde	44.05	0.783	-123.7	-	20.2	25.1	461.0	-	-166.2(g)	-1192.4 (g)
Ethanol	46.07	0.789	-114.6	5.021	78.5	38.58	516.3	63.0	-277.63(l) -235.31(g)	-1366.91(l) -1409.25(g)
Hydrogen	2.016	-	-259.19	0.12	-252.76	0.904	33.3	12.8	0 (g)	-285.84 (g)

Heat Capacities

Compound	State	Temperature unit	a x 10^3	b x 10^5	c x 10^8	d x 10^{12}	Range (unit of T)
Ethanol	l	°C	158.8	-	-	-	0-100
Hydrogen	g	°C	28.84	0.00765	0.3288	-0.8698	0-1500

For acetaldehyde, the heat capacity is given by Reid, Prausnitz and Poling:

$$C_p = 0.05048 + 1.326 \times 10^{-4} T - 8.050 \times 10^{-8} T^2 + 2.380 \times 10^{-11} T^3$$

$\hat{H}$(kJ/mol)
Reference state: Gas, P_{ref} = 1 atm, T_{ref} = 25°C

T	Air	O_2	N_2	H_2	CO	CO_2	H_2O
0	−0.72	−0.73	−0.73	−0.72	−0.73	−0.92	−0.84
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
100	2.19	2.24	2.19	2.16	2.19	2.90	2.54
200	5.15	5.31	5.13	5.06	5.16	7.08	6.01
300	8.17	8.47	8.12	7.96	8.17	11.58	9.57
400	11.24	11.72	11.15	10.89	11.25	16.35	13.23
500	14.37	15.03	14.24	13.83	14.38	21.34	17.01
600	17.55	18.41	17.39	16.81	17.57	26.53	20.91
700	20.80	21.86	20.59	19.81	20.82	31.88	24.92
800	24.10	25.35	23.86	22.85	24.13	37.36	29.05
900	27.46	28.89	27.19	25.93	27.49	42.94	33.32
1000	30.86	32.47	30.56	29.04	30.91	48.60	37.69
1100	34.31	36.07	33.99	32.19	34.37	54.33	42.18
1200	37.81	39.70	37.46	35.39	37.87	60.14	46.78
1300	41.34	43.38	40.97	38.62	41.40	65.98	51.47
1400	44.89	47.07	44.51	41.90	44.95	71.89	56.25
1500	48.45	50.77	48.06	45.22	48.51	77.84	61.09