T4 – CHANGEMENTS D'ETAT et MACHINES THERMIQUES

Travaux Dirigés

Exercice 3 : Détente isenthalpique

Table 1 (continued)
DuPont™ Freon® 12 Saturation Properties — Temperature Table

Temp °C	Pressure [kPa]	Volume [m³/kg] Liquid v_f	Volume [m³/kg] Vapour v_g	Density [kg/m³] Liquid d_f	Density [kg/m³] Vapour d_g	Enthalpy [kJ/kg] Liquid H_f	Enthalpy [kJ/kg] Latent H_{fg}	Enthalpy [kJ/kg] Vapour H_g	Entropy [kJ/K-kg] Liquid S_f	Entropy [kJ/K-kg] Vapour S_g	Temp °C
-20	150.7	0.0007	0.1098	1458.0	9.109	181.6	162.1	343.7	0.9305	1.5710	-20
-19	156.7	0.0007	0.1059	1455.0	9.446	182.5	161.6	344.1	0.9341	1.5700	-19
-18	162.8	0.0007	0.1021	1452.0	9.792	183.4	161.2	344.6	0.9376	1.5690	-18
-17	169.1	0.0007	0.0986	1449.0	10.150	184.3	160.8	345.1	0.9412	1.5690	-17
-16	175.6	0.0007	0.0951	1446.0	10.510	185.2	160.3	345.5	0.9447	1.5680	-16
-15	182.3	0.0007	0.0918	1443.0	10.890	186.1	159.9	346.0	0.9482	1.5670	-15
-14	189.2	0.0007	0.0887	1440.0	11.270	187.1	159.3	346.4	0.9517	1.5670	-14
-13	196.3	0.0007	0.0857	1437.0	11.670	188.0	158.9	346.9	0.9552	1.5660	-13
-12	203.6	0.0007	0.0828	1434.0	12.080	188.9	158.5	347.4	0.9587	1.5660	-12
-11	211.1	0.0007	0.0800	1431.0	12.500	189.8	158.0	347.8	0.9622	1.5650	-11
-10	218.8	0.0007	0.0774	1428.0	12.920	190.7	157.6	348.3	0.9656	1.5640	-10
-9	226.7	0.0007	0.0748	1425.0	13.370	191.6	157.1	348.7	0.9691	1.5640	-9
-8	234.8	0.0007	0.0724	1421.0	13.820	192.6	156.6	349.2	0.9726	1.5630	-8
-7	243.2	0.0007	0.0700	1418.0	14.280	193.5	156.2	349.7	0.9760	1.5630	-7
-6	251.8	0.0007	0.0678	1415.0	14.760	194.4	155.7	350.1	0.9795	1.5620	-6
-5	260.6	0.0007	0.0656	1412.0	15.240	195.3	155.3	350.6	0.9829	1.5620	-5
-4	269.6	0.0007	0.0635	1409.0	15.740	196.3	154.7	351.0	0.9863	1.5610	-4
-3	278.9	0.0007	0.0615	1406.0	16.260	197.2	154.3	351.5	0.9898	1.5610	-3
-2	288.4	0.0007	0.0596	1402.0	16.780	198.1	153.8	351.9	0.9932	1.5600	-2
-1	298.1	0.0007	0.0577	1399.0	17.320	199.1	153.3	352.4	0.9966	1.5600	-1
0	308.1	0.0007	0.0560	1396.0	17.870	200.0	152.8	352.8	1.0000	1.5590	0
1	318.4	0.0007	0.0542	1393.0	18.440	200.9	152.4	353.3	1.0030	1.5590	1
2	328.9	0.0007	0.0526	1390.0	19.020	201.9	151.8	353.7	1.0070	1.5590	2
3	339.7	0.0007	0.0510	1386.0	19.610	202.8	151.3	354.1	1.0100	1.5580	3
4	350.7	0.0007	0.0495	1383.0	20.220	203.8	150.8	354.6	1.0140	1.5580	4
5	362.0	0.0007	0.0480	1380.0	20.840	204.7	150.3	355.0	1.0170	1.5570	5
6	373.6	0.0007	0.0466	1377.0	21.480	205.7	149.7	355.4	1.0200	1.5570	6
7	385.4	0.0007	0.0452	1373.0	22.130	206.6	149.3	355.9	1.0240	1.5570	7

Table 1 (continued)
DuPont™ Freon® 12 Saturation Properties — Temperature Table

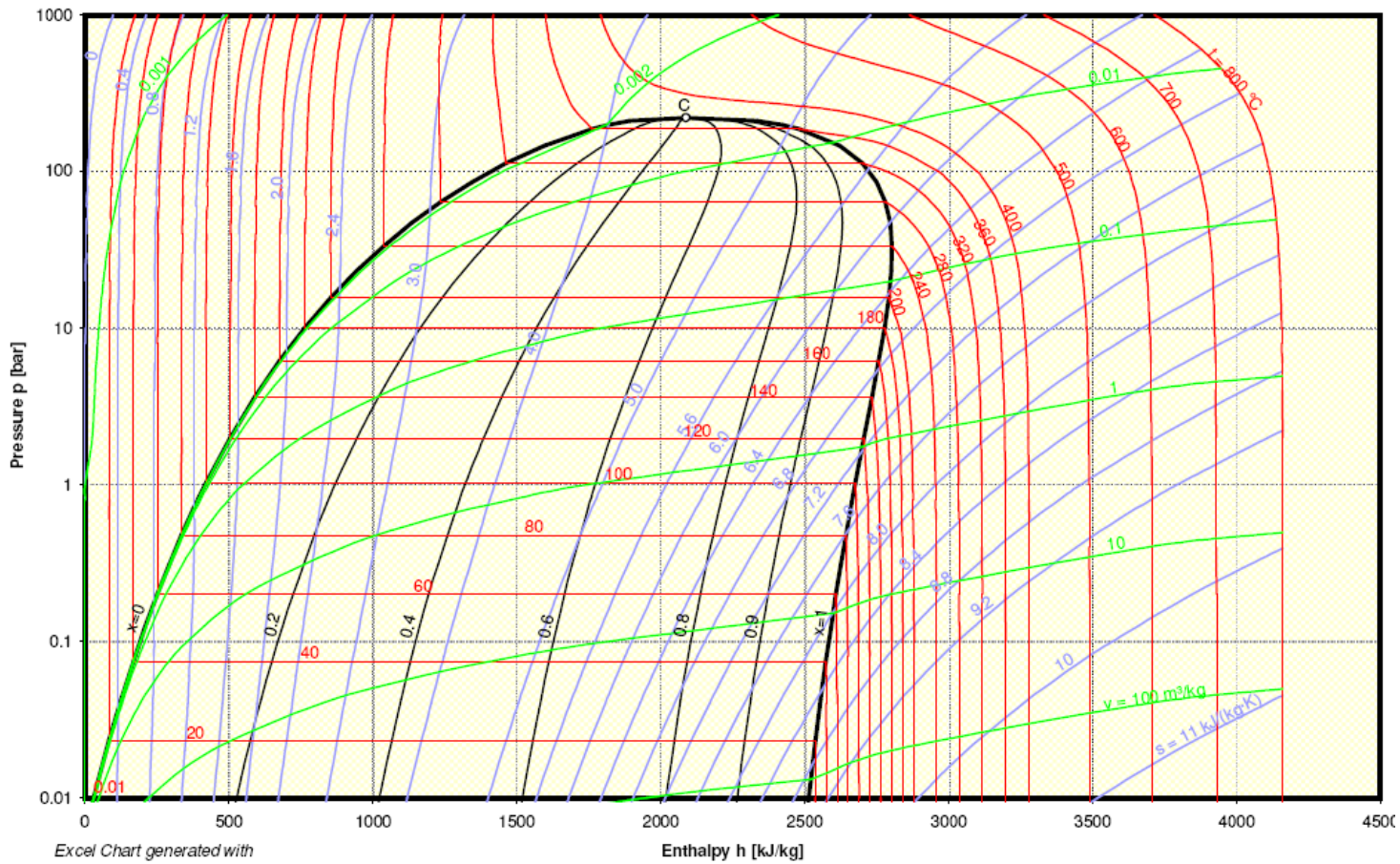| Temp °C	Pressure [kPa]	Volume [m³/kg] Liquid v_f	Volume [m³/kg] Vapour v_g	Density [kg/m³] Liquid d_f	Density [kg/m³] Vapour d_g	Enthalpy [kJ/kg] Liquid H_f	Enthalpy [kJ/kg] Latent H_{fg}	Enthalpy [kJ/kg] Vapour H_g	Entropy [kJ/K-kg] Liquid S_f	Entropy [kJ/K-kg] Vapour S_g	Temp °C
8	397.6	0.0007	0.0439	1370.0	22.800	207.6	148.7	356.3	1.0270	1.5560	8
9	410.0	0.0007	0.0426	1367.0	23.480	208.5	148.2	356.7	1.0300	1.5560	9
10	422.7	0.0007	0.0414	1363.0	24.180	209.5	147.7	357.2	1.0340	1.5550	10
11	435.7	0.0007	0.0402	1360.0	24.900	210.4	147.2	357.6	1.0370	1.5550	11
12	448.9	0.0007	0.0390	1356.0	25.630	211.4	146.6	358.0	1.0400	1.5550	12
13	462.5	0.0007	0.0379	1353.0	26.380	212.3	146.2	358.5	1.0440	1.5540	13
14	476.4	0.0007	0.0368	1350.0	27.150	213.3	145.6	358.9	1.0470	1.5540	14
15	490.6	0.0007	0.0358	1346.0	27.930	214.3	145.0	359.3	1.0500	1.5540	15
16	505.1	0.0007	0.0348	1343.0	28.740	215.2	144.5	359.7	1.0540	1.5530	16
17	520.0	0.0007	0.0338	1339.0	29.560	216.2	143.9	360.1	1.0570	1.5530	17
18	535.1	0.0008	0.0329	1336.0	30.400	217.2	143.3	360.5	1.0600	1.5530	18
19	550.6	0.0008	0.0320	1332.0	31.260	218.2	142.8	361.0	1.0640	1.5520	19
20	566.4	0.0008	0.0311	1329.0	32.130	219.1	142.3	361.4	1.0670	1.5520	20
21	582.6	0.0008	0.0303	1325.0	33.030	220.1	141.7	361.8	1.0700	1.5520	21
22	599.0	0.0008	0.0295	1322.0	33.950	221.1	141.1	362.2	1.0740	1.5510	22
23	615.9	0.0008	0.0287	1318.0	34.890	222.1	140.5	362.6	1.0770	1.5510	23
24	633.0	0.0008	0.0279	1315.0	35.850	223.1	139.9	363.0	1.0800	1.5510	24
25	650.6	0.0008	0.0272	1311.0	36.830	224.1	139.3	363.4	1.0830	1.5510	25
26	668.5	0.0008	0.0264	1307.0	37.830	225.1	138.7	363.8	1.0870	1.5500	26
27	686.7	0.0008	0.0257	1304.0	38.850	226.0	138.2	364.2	1.0900	1.5500	27
28	705.3	0.0008	0.0251	1300.0	39.900	227.0	137.5	364.5	1.0930	1.5500	28
29	724.3	0.0008	0.0244	1296.0	40.970	228.0	136.9	364.9	1.0960	1.5490	29
30	743.7	0.0008	0.0238	1293.0	42.070	229.0	136.3	365.3	1.1000	1.5490	30
31	763.4	0.0008	0.0232	1289.0	43.180	230.0	135.7	365.7	1.1030	1.5490	31
32	783.5	0.0008	0.0226	1285.0	44.330	231.1	135.0	366.1	1.1060	1.5490	32
33	804.0	0.0008	0.0220	1281.0	45.490	232.1	134.3	366.4	1.1090	1.5480	33
34	824.9	0.0008	0.0214	1278.0	46.690	233.1	133.7	366.8	1.1130	1.5480	34
35	846.2	0.0008	0.0209	1274.0	47.910	234.1	133.1	367.2	1.1160	1.5480	35

Exercice 11 : Machine frigorifique

Le diagramme ci-dessous représente le cycle de fonctionnement d'une machine frigorifique réelle. Déterminer l'efficacité réelle de cette machine ainsi que l'efficacité de Carnot d'une machine frigorifique réversible travaillant entre les mêmes températures : $T_C = 298\ K$ et $T_F = 263\ K$.

Figure 25.13 – Cycle d'une machine frigorifique : $T_{ch} = 298$ K, $T_{fr} = 263$ K.
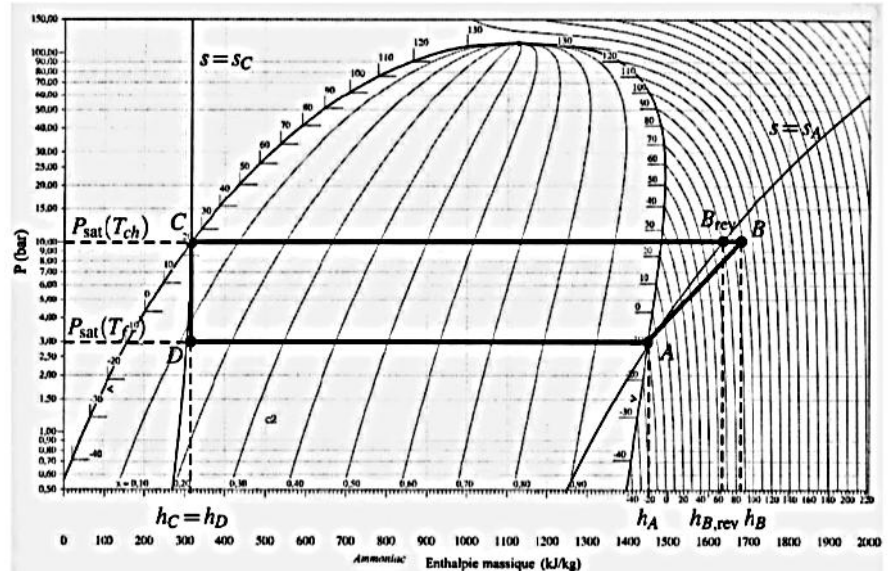
Exercice 13 : Machine à vapeur : Cycle de Rankine

logP-H diagram

Excel Chart generated with

Enthalpy h [kJ/kg]

Exercice 17 : Cycle réfrigérant au CO2 [oral banque PT]
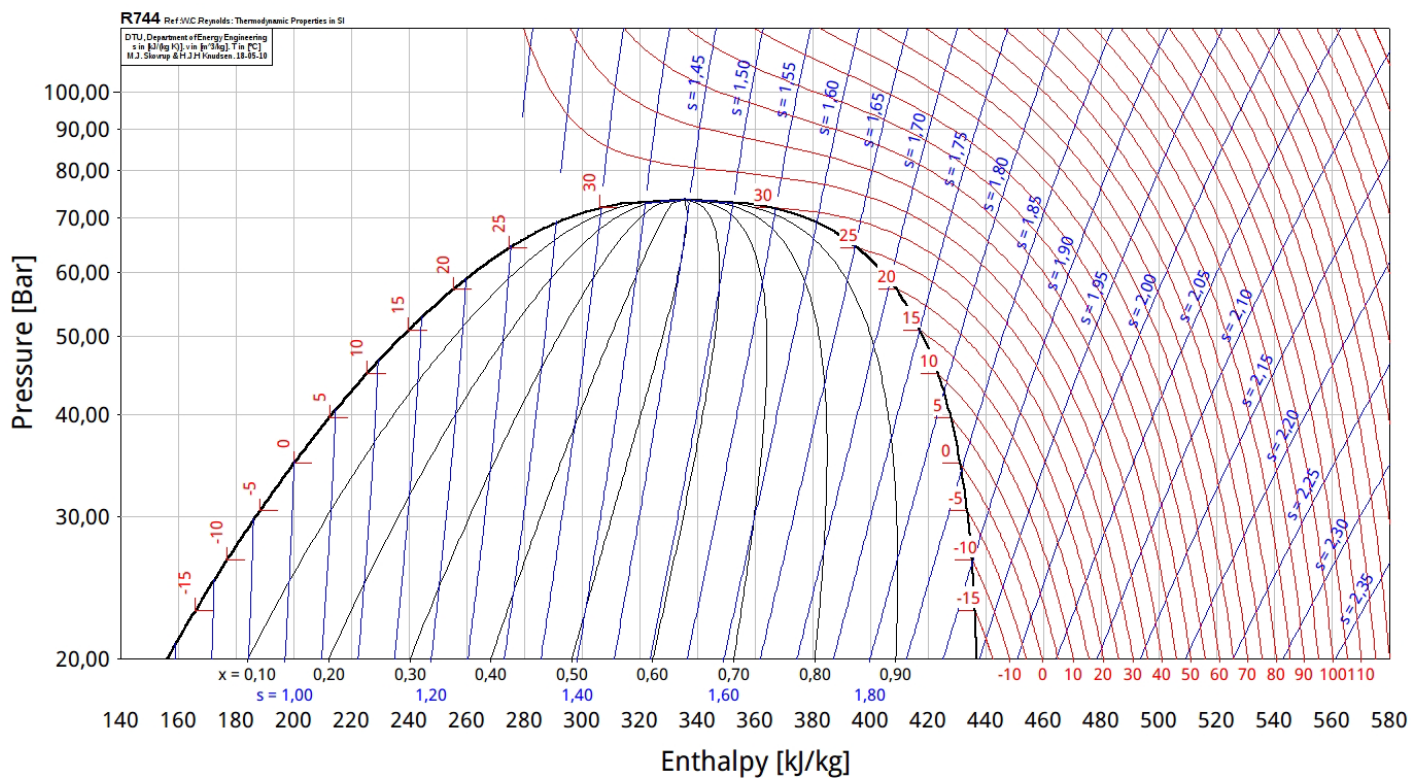
Figure 1 − Diagramme des frigoristes du CO2.

logP-H diagram

Excel Chart generated with

Enthalpy h [kJ/kg]
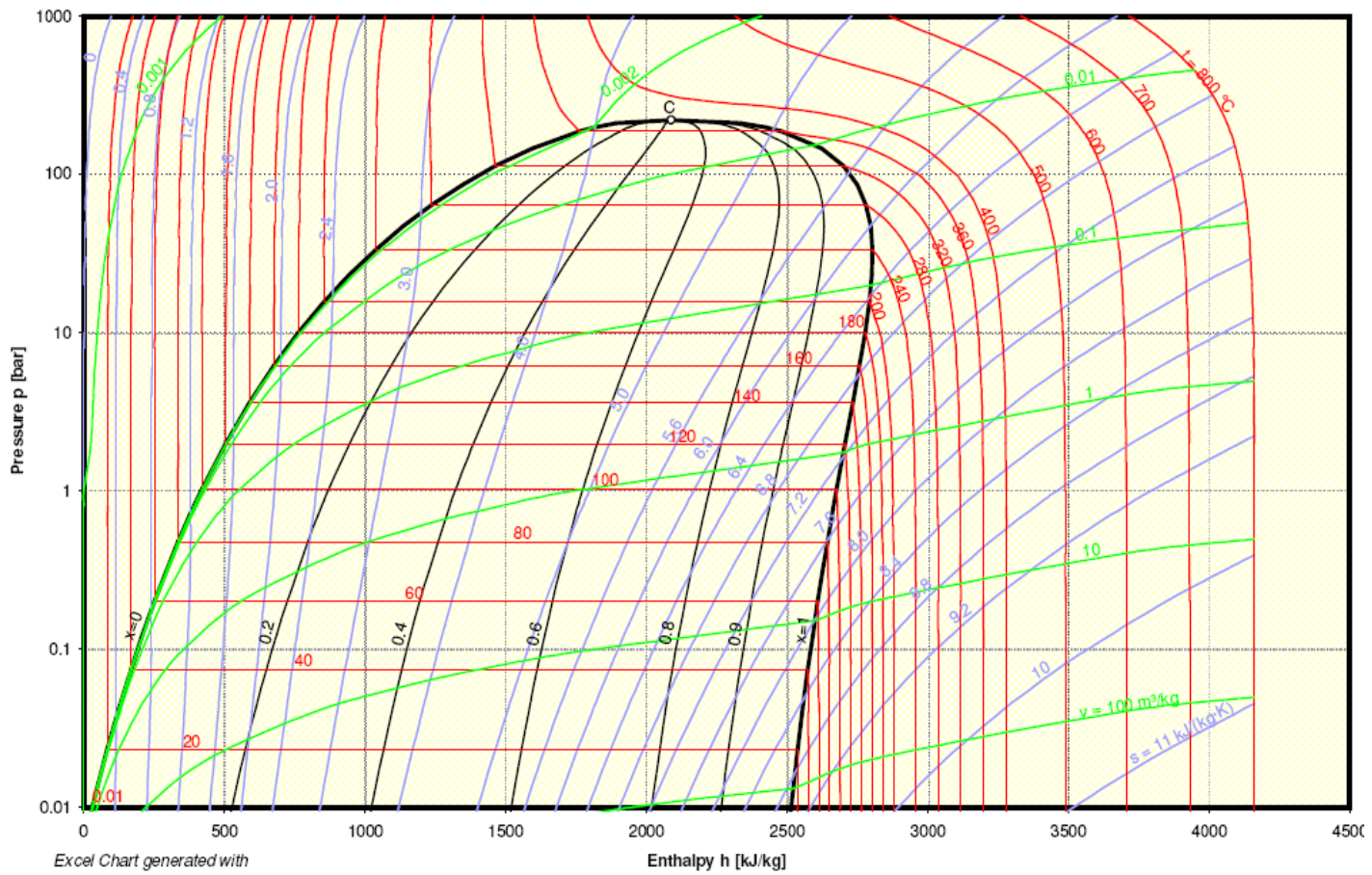
Ex 3

Courbe de saturation

rosée

ébullition

R134a Ref :D.P.Wilson & R.S.Basu, ASHRAE Transactions 1988, Vol.94 part 2.
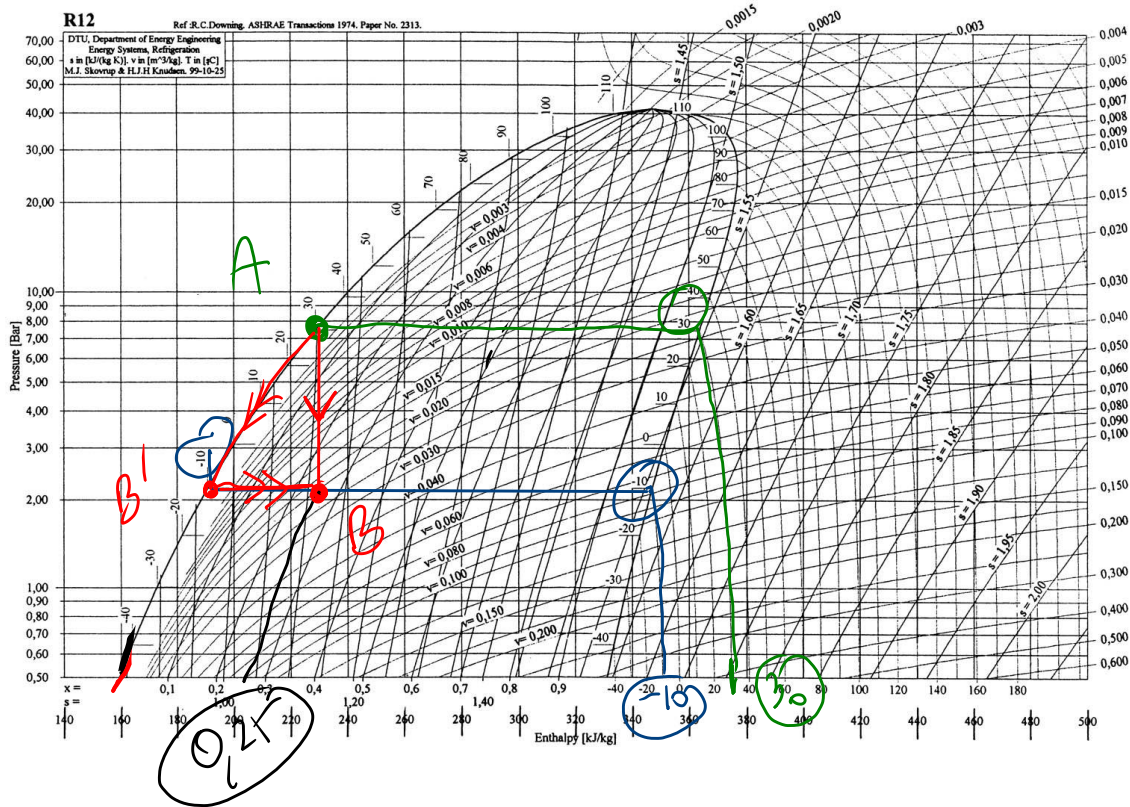
DTU, Department of Energy Engineering
s in [kJ/(kg K)], v in [m³/kg], T in [C]
M.J. Skovrup & H.J.H Knudsen. 03-05-04

Diagramme entropique de la vapeur d'eau

Point critique :
$T_c = 374,15\ °C$
$P_c = 221,20\ bar$
$v_c = 0,00317\ m^3.kg^{-1}$
$h_c = 2107,4\ kJ.kg^{-1}$
$s_c = 4,4429\ kJ.kg^{-1}.K^{-1}$

Unités : T en °C
P en bar
v en $m^3.kg^{-1}$
h en $kJ.kg^{-1}$
s en $kJ.kg^{-1}.K^{-1}$

Annexe 5

Annexe 5

R134a Ref D F Wilson & R S Basu, ASHRAE Transactions 1988, Vol. 94 part 2.

h représente l'enthalpie massique en kJ.kg⁻¹

P représente la pression exprimée en bar

x représente la fraction massique en vapeur
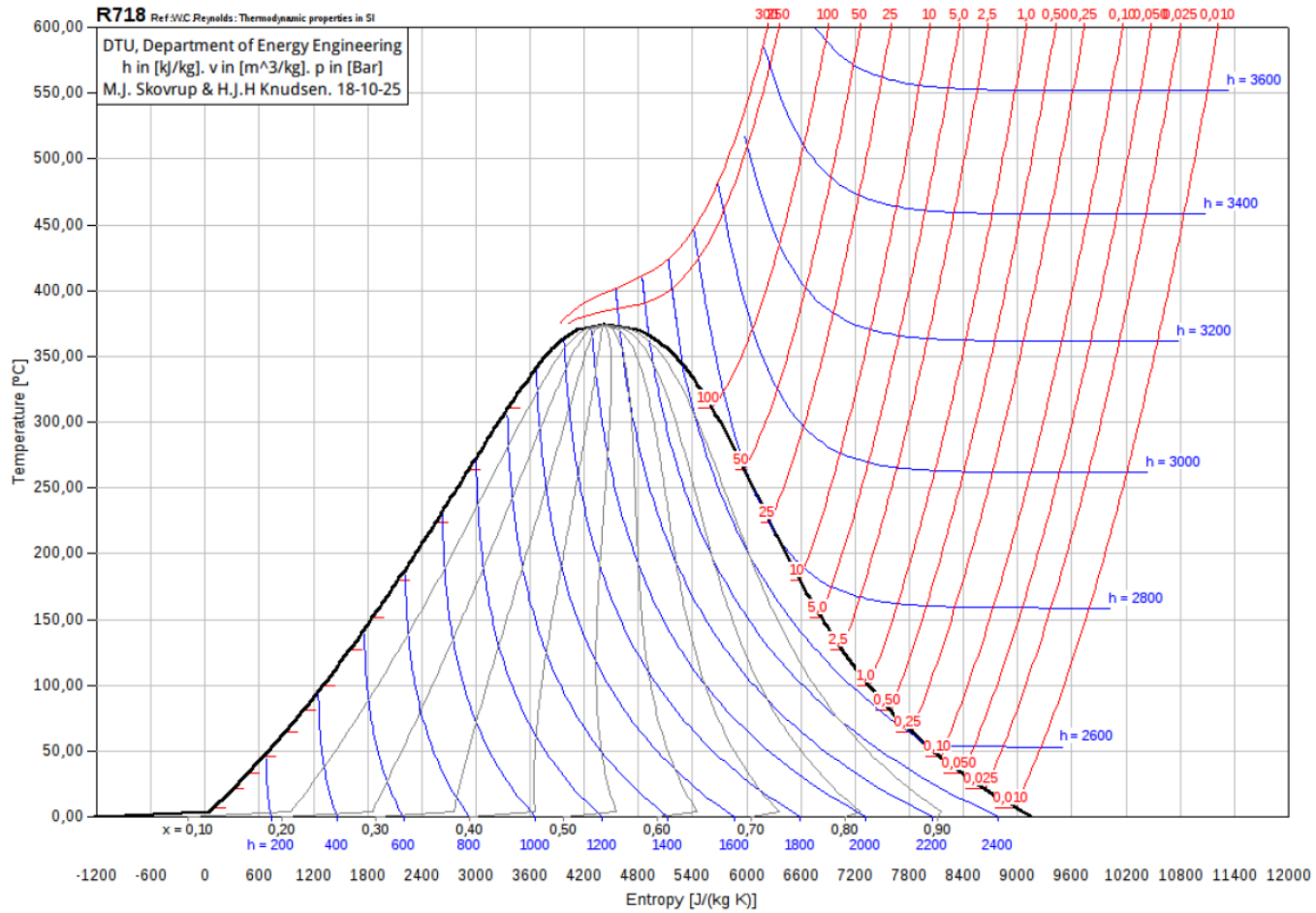
Document réponse (à rendre avec la copie)

Courbe d'ébullition

Courbe de rosée
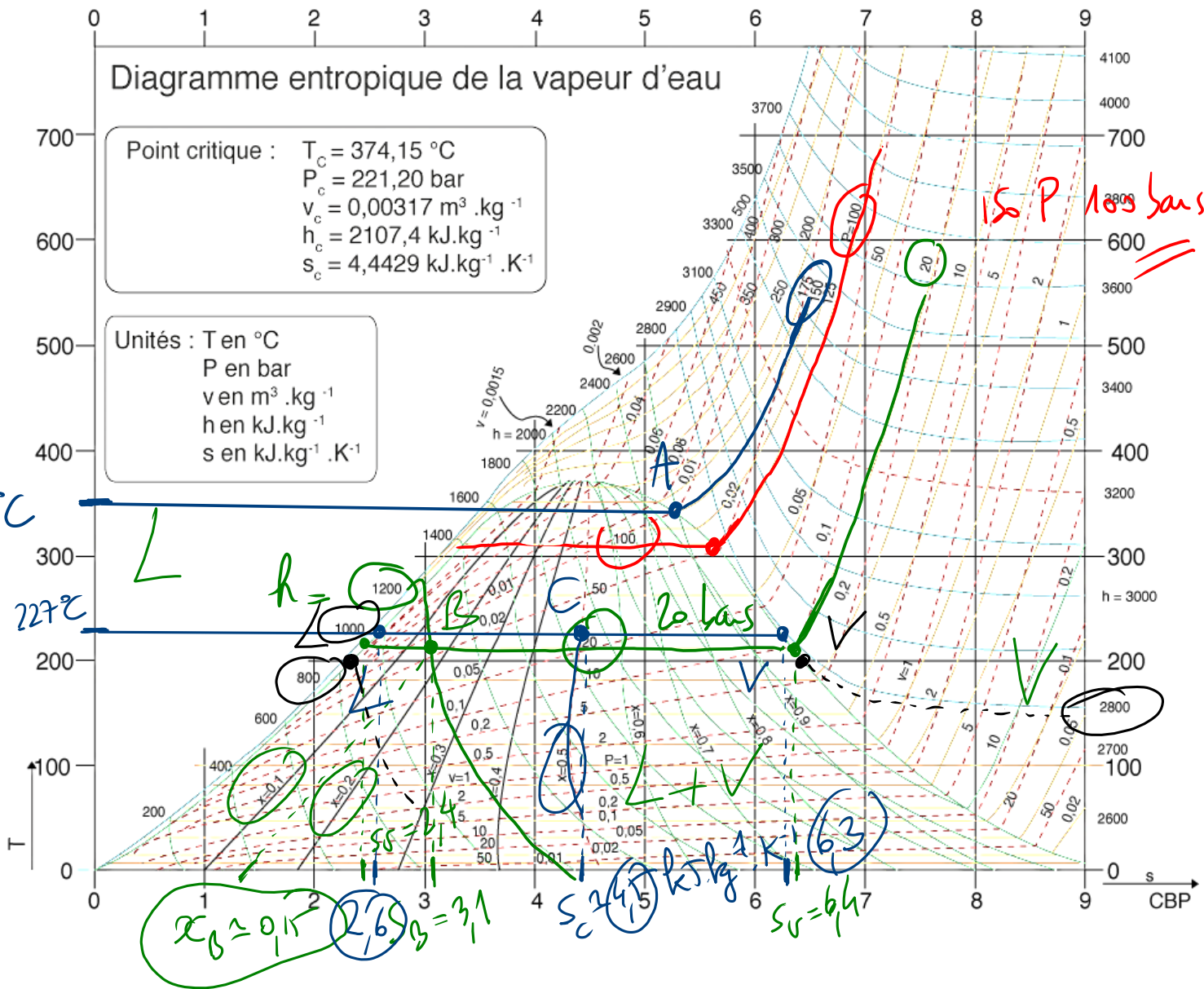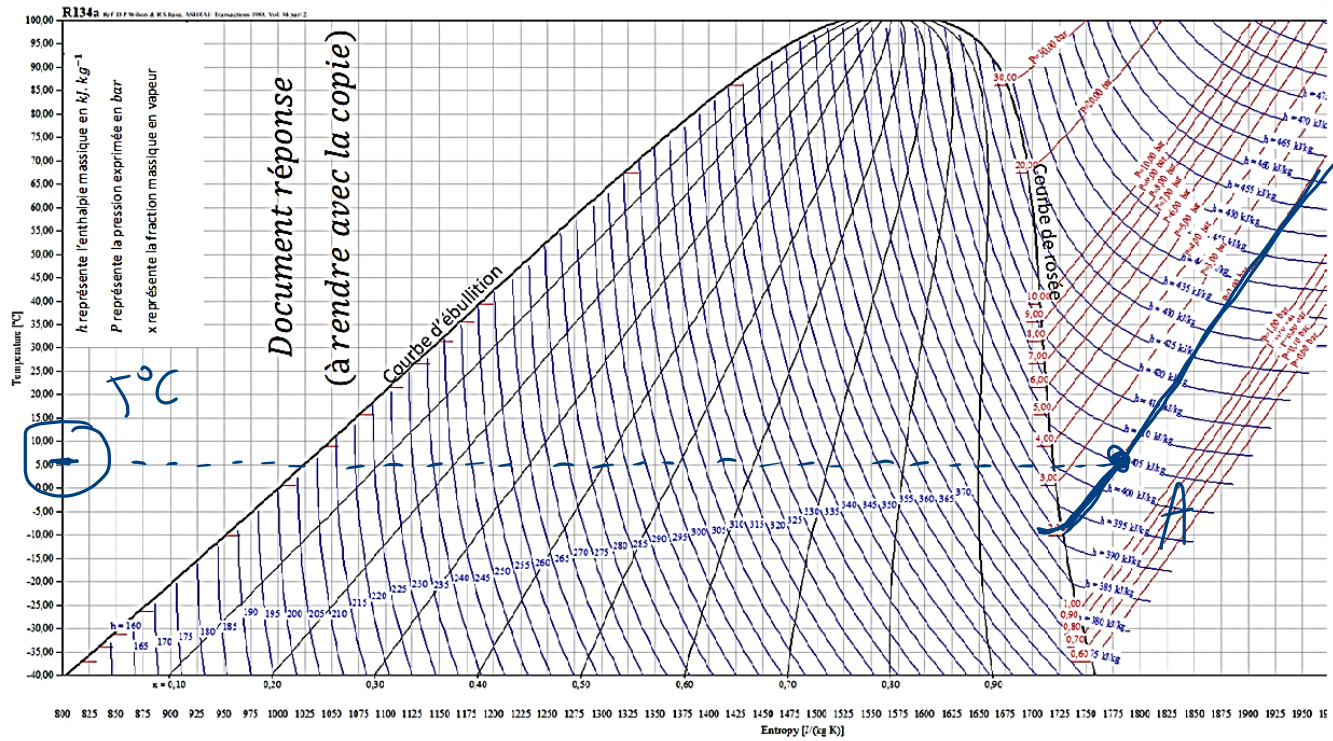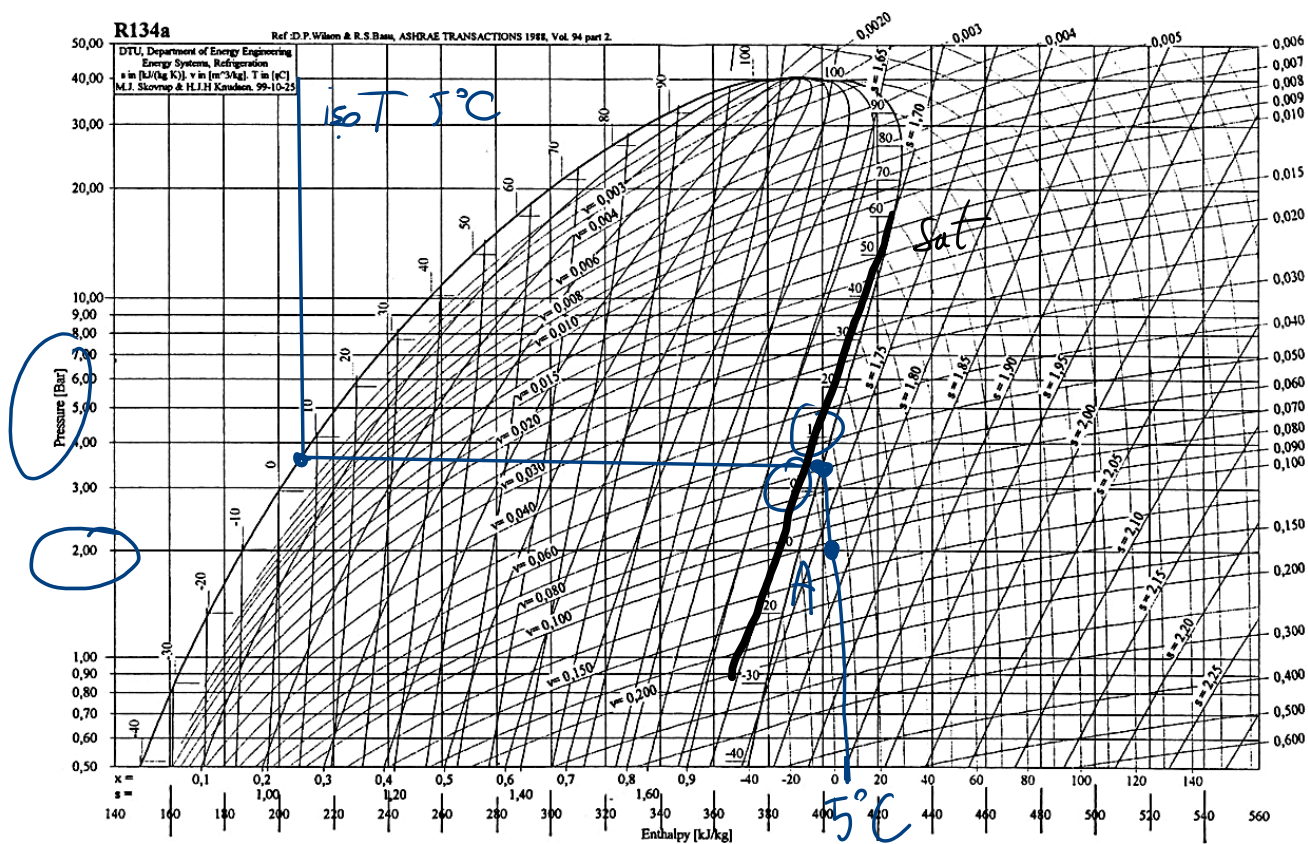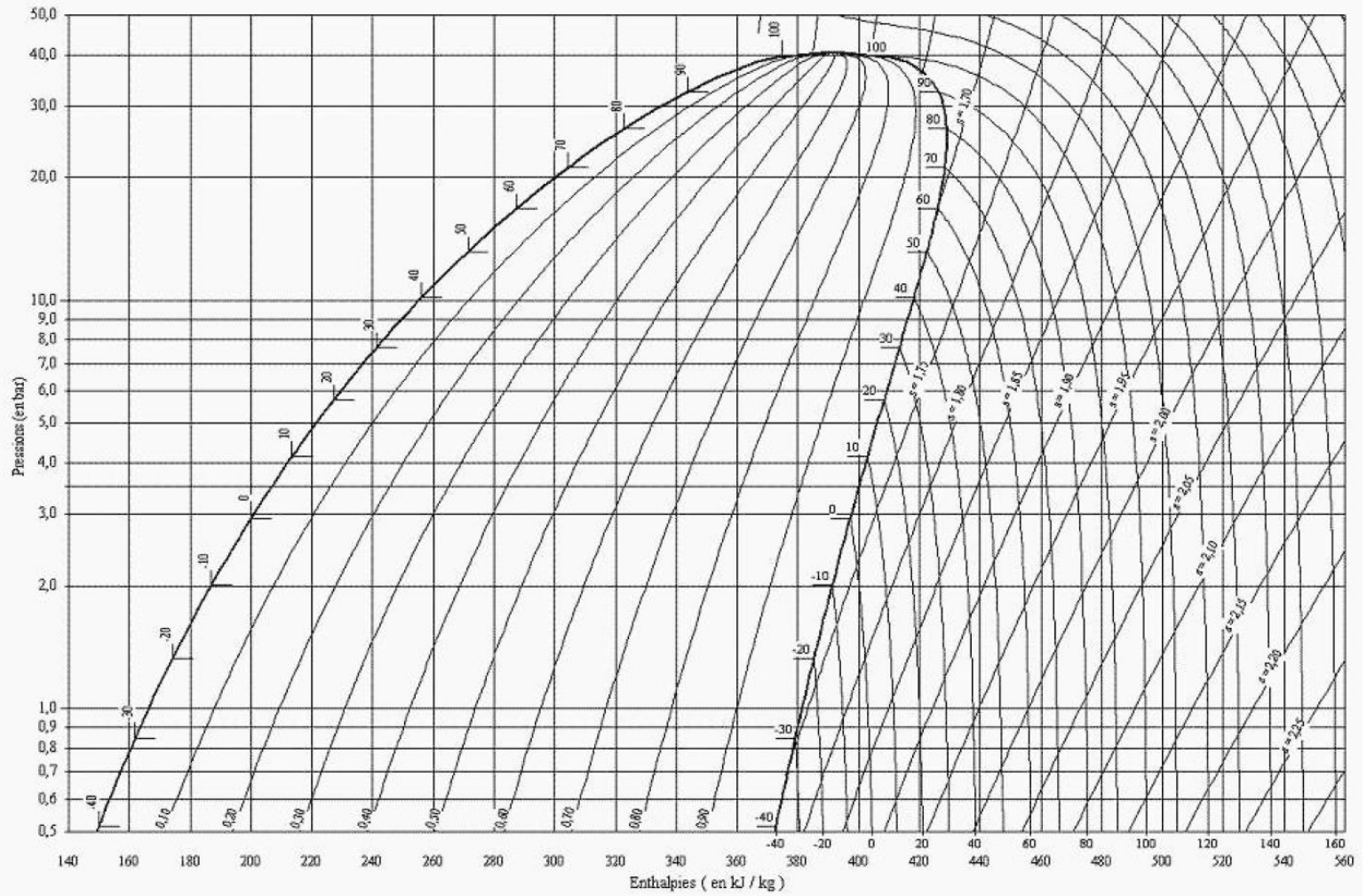
Figure 18 – Diagramme entropique de l'eau.