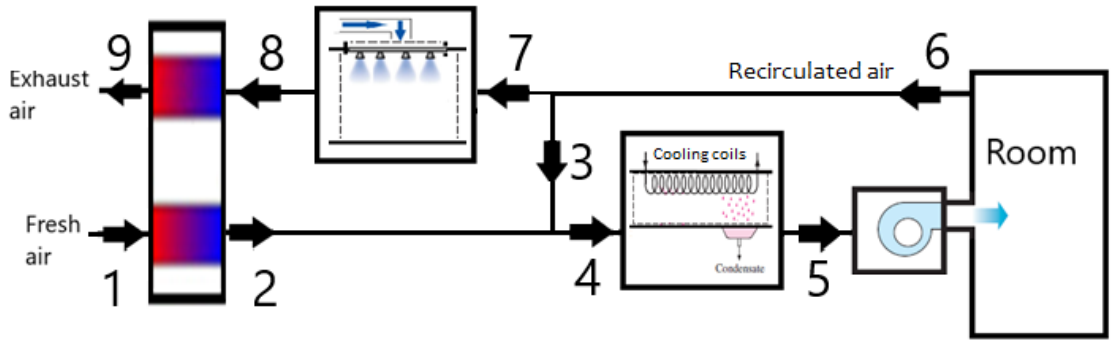
Exercise 2

The following data are known from an summer air conditioning unit (with heat recovery and humidifier in extraction stream):



Dry air mass flow (state 1):	1.50 kg/s	Dry air mass flow (state 3):	0.50 kg/s
Dry bulb temperature (state 1):	33.0 ºC	Relative humidity (state 1):	44.0 %
Dry bulb temperature (state 2):	27.0 ºC	Dry bulb temperature (state 3):	22.0 ºC
Relative humidity (state 3):	60.0 %		

Humidifier efficiency:	55.0 %	Water temperature:	16.0 ºC
Bypass factor:	6.00 %	Apparatus dew-point:	12.0 ºC

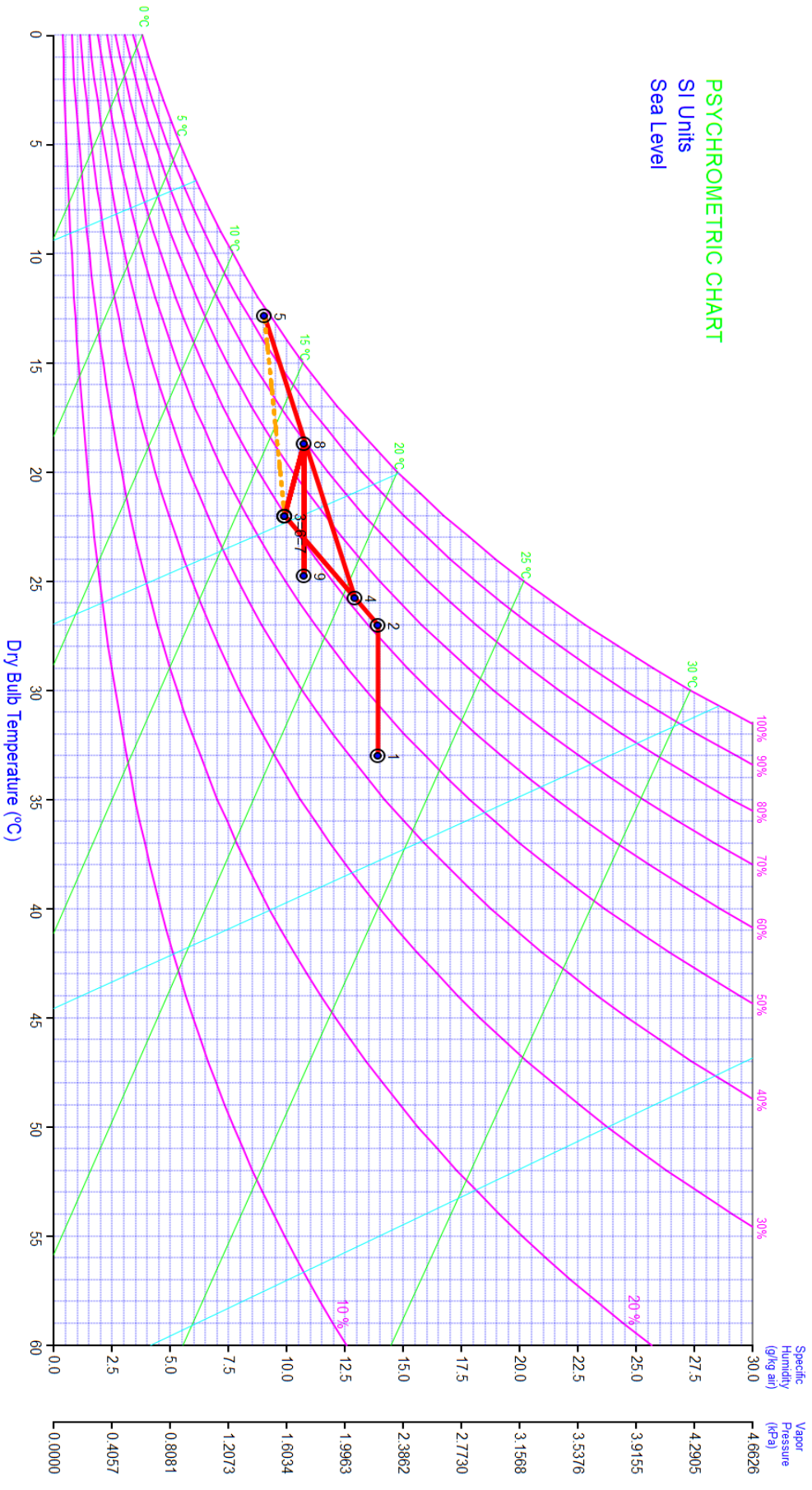
Dead state: 101325 Pa, 4ºC, 70%

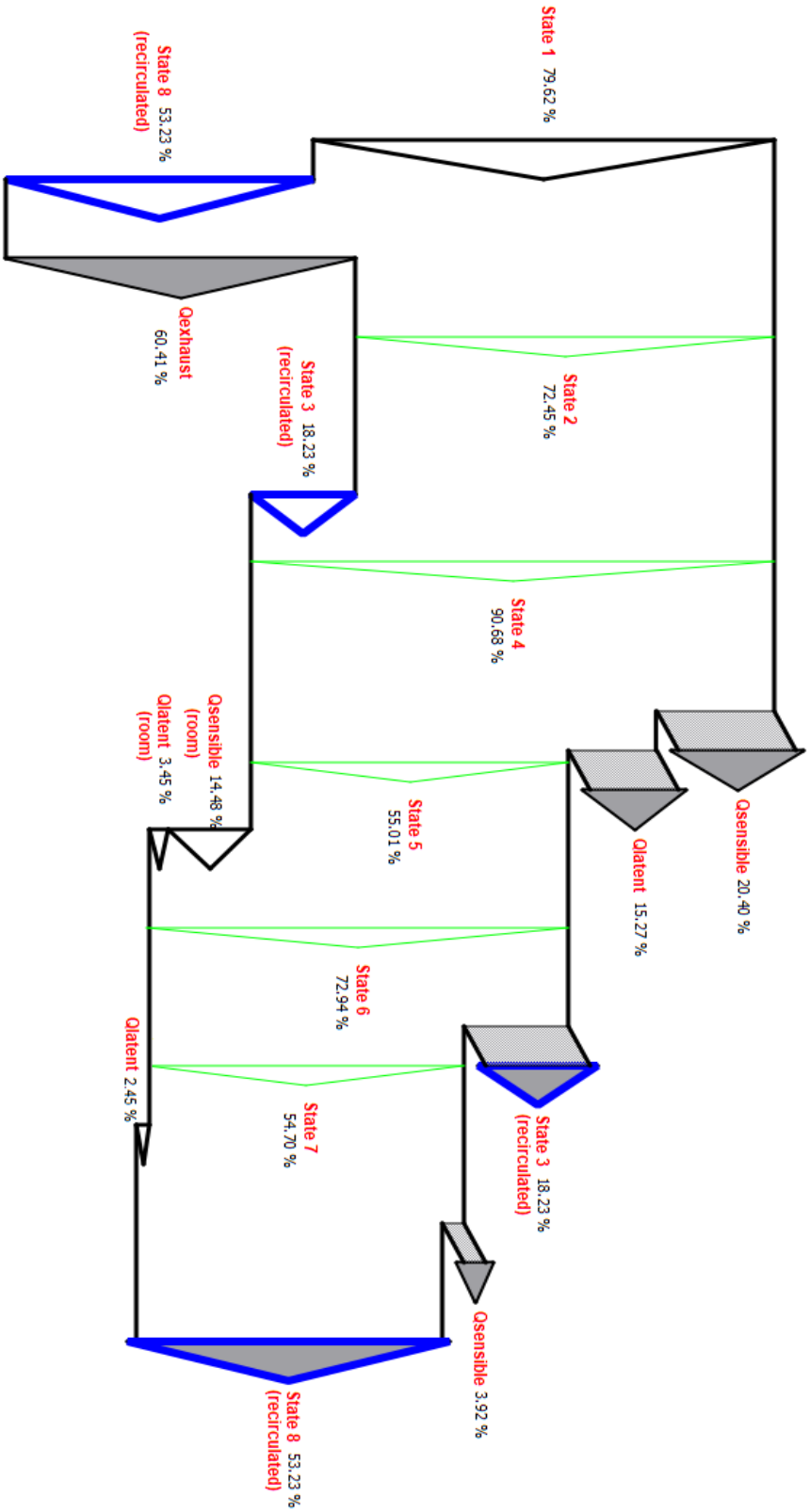
Air-conditioning is that process used to create and maintain certain temperature, relative humidity and air purity conditions in indoor spaces. This process is typically applied to maintain a level of personal comfort. The main process underlying air-conditioning is the exchange of heat and water vapour between the indoor and outdoor environments and the people inside the air-conditioned space. An air-conditioning system must be effective regardless of outside climatic conditions and involves control over four fundamental variables: air temperature, humidity, movement and quality.

Results	1-2	2-3-4	4-5	7-8	8-9	Room	Net	Units
Delta-RH	18.0946		35.6307	19.6988	-24.5977	-37.7731	11.0533	%
Delta-Tdb	-6.00001		-12.925	-3.30414	6.03683	9.17499	-7.01733	°C
Delta-Twb	-1.69986		-7.83218	-0.453186	2.06125	4.25021	-3.67377	°C
Delta-v	-0.0175128		-0.0425138	-0.00842369	0.0173792	0.0276165	-0.0234546	m³/kg
Delta-h	-6.19643		-23.1232	-1.26791	6.19643	11.6214	-12.7697	kJ/kg
Delta-s	-0.0204245		-0.0795371	-0.00415538	0.0209974	0.0400913	-0.0430283	kJ/kg °C
Sensible heat	-9.29464		-26.4473	-5.07915		18.773	-22.0481	KW
Latent heat			-19.799	3.17728		4.46987	-12.1518	kW
Total heat	-9.29464		-46.2463	-1.90187		23.2429	-34.1999	kW
Energy efficiency		100	100	94.7758	27.1773			%
Generated entropy		0.00016647	0.00435005	0.00011683	0.000862295	0.00263182	0.00812746	kW/°C
Irreversibility		0.0461372	1.20562	0.0323794	0.238985	0.729409	2.25253	kW
Exergy efficiency		98.7145	65.97	88.6373	95.5232			%
Water mass flow			0.00777337					kg/s
Water temperature				16				°C
Humidifier efficiency				55				%
Bypass factor			6					%
Apparatus dew-point			12					°C
Recuperator efficiency	41.9459							%
Recirculated air								
Coil sensible HF (CSHF)			0.571879	0.615175				
Room sensible HF (RSHF)						0.807689		

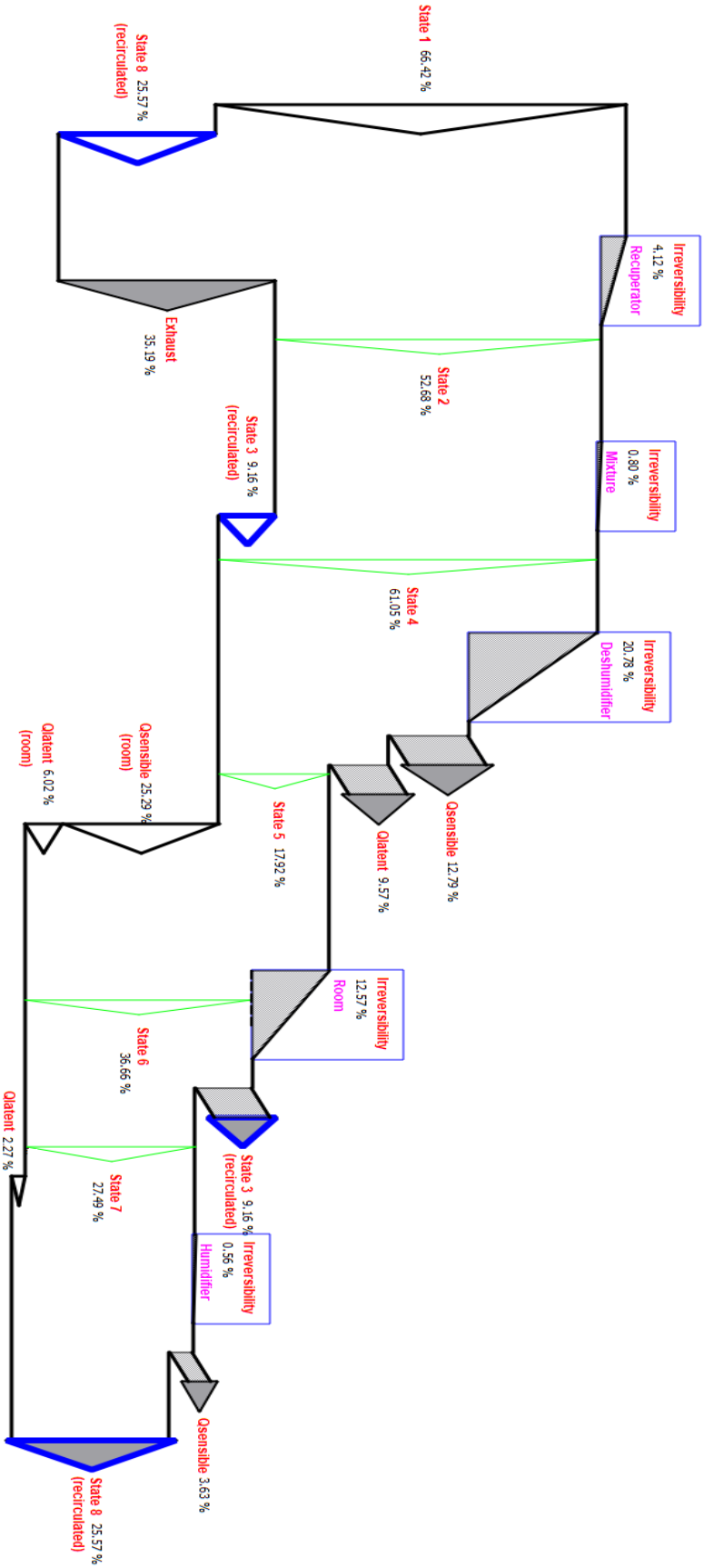
Variable	State 1	State 2	State 3	State 4	State 5	State 6	State 7	State 8	State 9	Units
Pressure	101325	101325	101325	101325	101325	101325	101325	101325	101325	Pa
Dry bulb temperature	33	27	22	25.75	12.825	22	22	18.6959	24.7327	°C
Relative humidity	44	62.0946	60	62.1424	97.7731	60	60	79.6988	55.1011	%
Humidity at saturation	32.5187	22.6968	16.6698	21.0287	9.2243	16.6698	16.6698	13.5249	19.7543	g/kg air
Specific humidity	13.9012	13.9012	9.89577	12.9026	9.01591	9.89577	9.89577	10.7318	10.7318	g/kg air
Degree of saturation	0.427483	0.612473	0.593636	0.613571	0.977408	0.593636	0.593636	0.793485	0.543263	
Dew temperature	19.123	19.123	13.8835	17.9583	12.4797	13.8835	13.8835	15.1173	15.1173	°C
Wet bulb temperature	23.2416	21.5418	16.872	20.4539	12.6218	16.872	16.872	16.4188	18.48	°C
Density	1.12805	1.15078	1.17765	1.15742	1.21732	1.17773	1.17765	1.18945	1.16536	kg/m³
Specific volume	0.886486	0.868973	0.849151	0.863989	0.821476	0.849092	0.849151	0.840727	0.858107	m³/kg
Saturation pressure	5034.59	3567.49	2644.89	3313.87	1480.83	2644.89	2644.89	2156.52	3119.22	Pa
Vapor pressure	2215.22	2215.22	1586.93	2059.32	1447.85	1586.93	1586.93	1718.72	1718.72	Pa
Enthalpy	68.8045	62.6081	47.2725	58.7742	35.651	47.2725	47.2725	46.0045	52.201	kJ/kg air
Entropy	0.243136	0.222712	0.170229	0.209675	0.130138	0.170229	0.170229	0.166073	0.187071	kJ/kg air °C
Air pressure	99109.8	99109.8	99738.1	99265.7	99877.1	99738.1	99738.1	99606.3	99606.3	Pa
Total exergy	2.56955	2.03811	1.06354	1.7714	0.519863	1.06354	1.06354	0.989331	1.36145	kJ/kg air
Thermal exergy	1.46557	0.934131	0.574294	0.836136	0.140756	0.574294	0.574294	0.3863	0.758415	kJ/kg air
Mechanical exergy	0	0	0	0	0	0	0	0	0	kJ/kg air
Chemical exergy	1.10398	1.10398	0.489243	0.935266	0.379107	0.489243	0.489243	0.60303	0.60303	kJ/kg air
Dry air mass flow	1.5	1.5	0.5	2	2	2	1.5	1.5	1.5	kg air/s
Volume flow	1.32973	1.30346	0.424576	1.72798	1.64295	1.69818	1.27373	1.26109	1.28716	m³/s

Exergy balances, which allow exergy destruction rates and exergy efficiencies to be determined, for the main components of the installation, that is, the heat exchangers, coiling coils, humidifier and in the room.


PSYCHROMETRIC CHART
SI Units
Sea Level
Dry Bulb Temperature (°C)
Specific Humidity (g/kg air)
Vapor Pressure (kPa)
0 °C
5 °C
10 °C
15 °C
20 °C
25 °C
30 °C
100%
90%
80%
70%
60%
50%
40%
30%
20 %
10 %
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0
0.0000
0.4057
0.8081
1.2073
1.6034
1.9963
2.3862
2.7730
3.1568
3.5376
3.9155
4.2905
4.6626



Energy diagram



Exergy diagram (Grassmann diagram)