UNIVERSITY OF JOHANNESBURG

PROGRAM	:	Bachelor of Engineering Technology ENGINEERING: MECHANICAL
SUBJECT	:	**REFRIGERATION AND AIR CONDITIONING**
CODE	:	**RACMIB 3**
DATE	:	14 November 2019
DURATION	:	180 minutes
TOTAL MARKS	:	100

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NUMBER OF PAGES	:	5 PAGES

INSTRUCTIONS:

1. ANSWER ALL QUESTIONS PROVIDED.
2. MARKS WILL BE DEDUCTED FROM ANSWERS WITHOUT UNITS.
3. ANSWERS WITHOUT WORKING WILL NOT BE CONSIDERED.
4. WHERE OMITTED, ASSUME THE NECESSARY CONSTANTS FOR YOUR SOLUTIONS
5. CHARTS AND TABLES ARE PROVIDED

REQUIREMENTS: ONE CALCULATOR IS PERMITTED

QUESTION 1

1.1. Tshwane city hall requires an air conditioning system that maintains the room conditions at 22 ^{o}C dry bulb temperature and 50% relative humidity. The system is mixing 25% of fresh air by mass with 75 % recirculated air. The fresh air is at 35 ^{o}C dry bulb temperature and 28 ^{o}C wet bulb temperature and is added to the system at a rate of 50 m^3/ min. For a by-pass factor of the cooling coil of 0.18 and the ADP of 8.5 ^{o}C, determine the mass of air after mixing, the condition of air after cooling and the capacity of the cooling coil. Show the points on the psychrometric chart provided.

(16)

1.2. Explain the winter air conditioning system. (10)

[26]

QUESTION 2

2.1. A vapour compression refrigerator using R134a refrigerant is operating between pressure limits of 1.6389 bar and 4.8734 bar. The refrigerant is dry saturated at the entry to the compressor and is undercooled by 5 ^{o}C before entering the expansion valve. What is the mass flow of refrigerant and the power required to run the unit for 5 TR refrigeration capacity?

(10)

2.2. Consider the same system (i.e. working with same temperature limits), in which the refrigerant is now R22. For the same 5 TR refrigeration capacity, evaluate if this change is more economical. Coment on the results.

(13)

2.3. Considering other aspects (i.e. environmental), what refrigerant would you recommend. Explain your reasons.

(4)

[27]

QUESTION 3

3.1. In rural Northern Cape, a modular building is proposed to be used for the community school. The building is made of Nutec sheets interior and exterior walls of 10 mm thickness. The total wall thickness is 95 mm with the air gap cavity of 75 mm. You are required to calculate the rate of heat loss per unit surface of wall area when the inside and outside temperatures are 20 °C and -2 °C respectively. The heat transfer coefficient of the inside and outside surface of the wall is 8.9 W/m^{2}K, the thermal conductivity of the wall is 0.19 W/m K and the resistance to heat flow of the air gap is 0.16 K/W. Determine the temperature at each interface throughout the wall.

(12)

3.2. A 25 mm polystyrene sheet with a thermal conductivity of 0.33 W/mK is bonded to the inner wall panel. Is this considered an improvement in the rate of heat loss? If yes, by how much?

(4)

3.3. State two assumptions required for the above problem.

(4)

[20]

QUESTION 4

4.1. One of the improvements of simple vapour compression system is the use of a flash chamber. Explain where in the system is this placed and what role has and what improvement brings to the system.

(6)

4.2. List desirable characteristics of the refrigerant-absorbent mixture used in vapour absorption refrigeration systems.

(4)

4.3. List four advantages of vapour compression refrigeration system over air refrigeration system

(4)

[14]

QUESTION 5

A system of two refrigerators is operating in series between temperature limits of 293K and 973K. The first refrigerator absorbs 1.5 kJ/s from the cold body and rejects heat energy at temperature T. The second refrigerator absorbs from the body at temperature T a quantity of energy equal to the one rejected by the first refrigerator, and rejects heat energy to the hot body. Assuming that both refrigerators operates on Carnot cycle with same COP, determine the temperature T, the COP and the rate at which heat energy is rejected to the hot body.

[13]

Properties of R134a

							Superheat			
Saturation values							10K		20K	
t_g	P_g	v_g	h_f	h_g	S_f	S_g	h	S	h	S
(°C)	(bar)	m^3/kg	(kJ/kg)		(kJ/kg K)		(kJ/kg)	(kJ/kg K)	(kJ/kg)	(kJ /kg K)
-45	0.3908	0.458	42.67	268.49	0.7716	1.7613	276.73	1.7973	284.89	1.8288
-40	0.5188	0.356	48.94	271.40	0.7987	1.7528	279.77	1.7895	288.12	1.8231
-35	0.6612	0.279	55.22	274.30	0.8253	1.7452	283.02	1.7818	291.59	1.8156
-30	0.8436	0.222	61.52	277.21	0.8514	1.7385	286.23	1.7752	295.02	1.8092
-25	1.0638	0.178	67.83	280.12	0.8771	1.7325	289.44	1.7694	298.44	1.8036
-20	1.3271	0.145	74.18	283.03	0.9023	1.7273	292.62	1.7645	301.84	1.7989
-15	1.6389	0.118	80.56	285.94	0.9272	1.7228	295.81	1.7603	305.24	1.7948
-10	2.0051	0.098	86.98	288.86	0.9517	1.7189	299.00	1.7567	308.64	1.7914
-5	2.4371	0.081	93.46	291.77	0.9760	1.7155	302.18	1.7536	312.05	1.7884
0	2.9252	0.068	100.00	294.69	1.0000	1.7128	305.36	1.7511	315.44	1.7861
5	3.4920	0.058	106.61	297.60	1.0238	1.7105	308.55	1.7491	318.84	1.7842
10	4.1390	0.049	113.29	300.50	1.0475	1.7086	311.71	1.7475	322.23	1.7828
15	4.8734	0.042	120.06	303.38	1.0709	1.7071	314.86	1.7463	325.59	1.7817
20	5.7024	0.036	126.92	306.22	1.0943	1.7060	317.97	1.7454	328.93	1.7809
25	6.6337	0.031	133.89	309.03	1.1176	1.7051	321.08	1.7448	332.25	1.7804
30	7.6752	0.027	140.96	311.79	1.1408	1.7044	324.12	1.7444	335.52	1.7802
35	8.8351	0.023	148.15	314.47	1.1641	1.7038	327.11	1.7442	338.75	1.7801
40	10.1219	0.020	155.47	317.07	1.1873	1.7033	330.03	1.7440	341.91	1.7802
45	11.5447	0.017	162.93	319.54	1.2105	1.7028	332.87	1.7440	345.04	1.7804
55	14.8368	0.013	178.33	324.04	1.2572	1.7012	338.01	1.7432	350.74	1.7803
65	18.7960	0.010	194.53	327.62	1.3047	1.6983	342.73	1.7424	356.19	1.7805

								SUPERHEAT (t - ts)									
	PRESSURE	VOLUME		ENTHALPY		ENTROPY		10 K			20 K			30 K			
ts	[bar]	[m3/kg]		[kJ/kg]		[kJ/kg K]											ts
	P	vf x 103	vg	hf	hg	Sf	Sg	v	h	s	v	h	s	V	h	s	
-80	0.1046	0.6581	1.7632	115.06	369.31	0.6356	1.9519	1.8565	374.6	1.9786	1.9496	380.02	2.0046	2.0425	385.55	2.0299	-80
-75	0.143	0.6638	1.2763	119.91	371.77	0.6604	1.9314	1.3426	377.14	1.9578	1.4087	382.63	1.9836	1.4746	385.24	2.0057	-75
-70	0.2052	0.6697	0.9409	124.81	374.23	0.6648	1.9125	0.9890	379.68	1.9387	1.0369	385.25	1.9642	1.0646	390.93	1.9591	-70
-65	0.2797	0.6758	0.7055	129.76	376.68	0.7088	1.895	0.741	382.22	1.921	0.7763	387.87	1.9463	0.6115	393.63	1.9710	-65
-60	0.3748	0.6821	0.5372	134.76	379.11	0.7325	1.6789	0.5639	384.74	1.9047	0.5904	390.48	1.9298	0.6168	396.32	1.9543	-60
-55	0.4947	0.6886	0.4148	139.83	381.53	0.756	1.8639	0.4352	387.25	1.8895	0.4555	393.08	1.9145	0.4757	399	1.9389	-55
-50	0.6439	0.6953	0.3246	144.96	383.92	0.7792	1.85	0.3404	389.74	1.8755	0.3561	395.66	1.9004	0.3717	401.66	1.9246	-50
-45	0.8271	0.7022	0.257	150.15	386.28	0.6022	1.8371	0.2695	392.21	1.8625	0.2618	398.23	1.8872	0.2941	404.34	1.9114	-45
-40	1.0495	0.7094	0.2057	155.41	388.61	0.8249	1.825	0.2157	394.65	1.8504	0.2256	400.17	1.8751	0.2353	406.98	1.8991	-40
-35	1.3168	0.7168	0.1664	160.74	390.9	0.8474	1.8138	0.1745	397.05	1.8391	0.1624	403.28	1.8637	0.1903	409.59	1.8877	-35
-30	1.6348	0.7245	0.1358	166.14	393.14	0.8698	1.8033	0.1425	399.42	1.8286	0.149	405.76	1.8532	0.1554	412.15	1.8771	-30
-25	2.0098	0.7326	0.1119	171.61	395.33	0.8919	1.7934	0.1173	401.74	1.8187	0.1227	408.21	1.6433	0.1280	414.74	1.8672	-25
-20	2.4483	0.7409	0.09284	177.14	397.47	0.9139	1.7842	0.09743	404.02	1.8095	0.1019	410.61	1.8341	0.1063	417.26	1.8580	-20
-15	2.9570	0.7496	0.07763	182.75	399.54	0.9356	1.7754	0.08150	406.24	1.8009	0.08529	412.97	1.8255	0.08900	419.74	1.8494	-15
-10	3.5430	0.7588	0.06534	188.43	401.56	0.9573	1.7671	0.06865	408.41	1.7927	0.07188	415.26	1.8174	0.07503	421.19	1.8414	-10
-5	4.2135	0.7683	0.05534	194.16	403.50	0.9787	1.7593	0.05820	410.52	1.7850	0.06097	417.54	1.8098	0.06367	424.58	1.8338	-5
0	4.9759	0.7763	0.04714	200.	405.36	1.	1.7518	0.04962	412.57	1.7777	0.05203	419.75	1.8026	0.05437	426.93	1.8267	0
5	5.8378	0.7889	0.04036	205.9	407.14	1.0212	1.7446	0.04254	414.54	1.7708	0.04464	421.89	1.7956	0.04668	429.23	1.8200	5
10	6.8078	0.8000	0.03471	211.88	408.84	1.0422	1.7378	0.03665	416.44	1.7642	0.0385	423.97	1.7894	0.04029	431.47	1.8137	10
15	7.8915	0.8118	0.02999	217.94	410.43	1.0631	1.7311	0.03171	418.26	1.7578	0.03336	425.99	1.7833	0.03494	433.65	1.8075	15
20	9.0993	0.8243	0.026	224.06	411.92	1.0839	1.7246	0.02755	419.99	1.7517	0.02903	427.92	1.7774	0.03044	435.77	1.8021	20
25	10.439	0.8377	0.02262	230.32	413.29	1.1046	1.7183	0.02403	421.63	1.7456	0.02536	429.78	1.7716	0.02662	437.81	1.7967	25
30	11.919	0.8519	0.01974	236.66	414.53	1.1253	1.7120	0.02103	423.16	1.7400	0.02223	431.55	1.7664	0.02338	439.79	1.7915	30
35	13.548	0.8673	0.01727	243.11	415.63	1.1459	1.7058	0.01845	424.58	1.7343	0.01955	433.23	1.7611	0.02059	441.68	1.7865	35
40	15.335	0.8839	0.01514	249.69	416.56	1.1666	1.6995	0.01624	425.87	1.7287	0.01725	434.80	1.7560	0.01820	443.49	1.7617	40
45	17.290	0.9020	0.01328	256.40	417.31	1.1873	1.6931	0.01432	427.03	1.7231	0.01526	436.27	1.7509	0.01613	445.21	1.7769	45
50	19.423	0.9219	0.01167	263.26	417.64	1.2081	1.686	0.01264	428.03	1.7175	0.01352	437.61	1.7458	0.01433	446.83	1.7723	50
55	21.744	0.9440	0.01025	270.32	418.12	1.2291	1.6795	0.01118	428.85	1.7117	0.01201	438.83	1.7408	0.01276	448.34	1.7677	55
60	24.266	0.9688	0.009001	277.59	418.09	1.2504	1.6721	0.009901	429.48	1.7058	0.01068	439.89	1.7357	0.01139	449.73	1.7632	60

THERMODYNAMIC PROPERTIES OF REFRIGERANT 22

Council for Scientific and Industrial Research

NMERI PSYCHROMETRIC CHART No 5

SEA LEVEL

Barometric pressure 101,32 kPa