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SET A

UNIVERSITI KUALA LUMPUR

MALAYSIA FRANCE INSTITUTE

FINAL EXAMINATION

JANUARY 2011 SESSION

SUBJECT CODE	:	FRB30303
SUBJECT TITLE	:	PRODUCTION OF REFRIGERATION
LEVEL	:	BACHELOR
TIME/DURATION	:	9.00 am – 12:00 pm 3 HOURS
DATE	:	9 May 2011

INSTRUCTIONS TO CANDIDATES

1. All documents authorized (Open Book Examination)
2. Please read the instructions given in the question paper CAREFULLY.
3. This question paper is printed on both sides of the paper.
4. Please write your answers on the answer booklet provided.
5. Answer should be written in blue or black ink except for sketching, graphic and illustration.
6. This question paper consists only one section. Answer all questions.
7. Answer all questions in English.

THERE ARE 3 PRINTED PAGES OF QUESTIONS AND 5 PAGES OF APPENDICE, EXCLUDING THIS PAGE

INSTRUCTION: Answer ALL questions.

Please use the answer booklet provided.

We consider a replacement of R-22 by R-507 in a chiller. The technical file of this installation was missing; we measure as per experiment below:

Refrigerating circuit:

Measurements where taken and recorded in the table as in appendix 1. It is noticed that the point of real discharge of the compressor is confused with isentropic discharge.

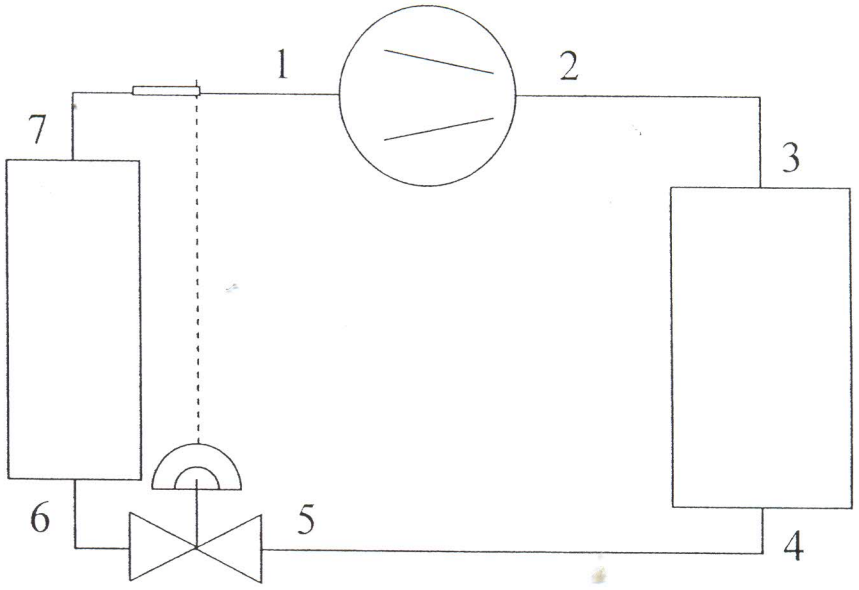
Evaporator

Glycol water inlet/ outlet: -15°c/-20°c

Air cooled condenser

Air inlet /outlet: 25°C/32°C

In addition, the table of the performances of the compressor is given in appendix 2.



PART A: Analyse the original

Question 1

To calculate the volumetric efficiency of the compressor, the refrigerating power produced at the evaporator, the heat rejected by the condenser, and the volume flow rate after expansion.

(2 marks)

Question 2

Calculate the effective efficiency of the compressor, its power absorbed in the above installation, and also its thermal losses towards ambient, and the COP of the installation.

(2 marks)

Question 3

Calculate the values of KS of the evaporator and the condenser of the installation. For the evaporator, we neglect the zone of de-superheat, and we considers that ALL the refrigerating power is produced by the zone of evaporation. For the condenser, we consider two zones: the first zone corresponds to the de-superheat of the vapour; the second zone is the remainder of the total condenser capacity, start from the HP dew point, until the end of sub cooled liquid.

(2 marks)

PART B: Replacement by R507

It is supposed that for identical pressures of operation, the volumetric efficiency and effective efficiency do not change from one fluid to another. Superheat and subcooled remain constant, and the discharge of the compressor is always confused with isentropic repression.

Question 4

For the mode -25°c/+35°c in R-507, indicate the saturated pressures.

(1 marks)

Question 5

To deduce the corresponding temperatures of saturation for R-22; using appendix 3, calculate the new efficiencies of the compressor.

(2 marks)

Question 6

Calculate the mass flow rate of R-507, the refrigerating power and the heat rejected at the condenser (thermodynamic coordinates of the R507 cycle in appendix 1).

(1.5 marks)

Question 7

For the secondary fluids, we maintain constant flow rate, the exit temperature of the evaporator and the entering temperature of the condenser. Calculate the KS values of the evaporator and the condenser, necessary for these powers. Calculate the evaporating temperature.

(2 marks)

Question 8

By using the value of evaporation temperature $\theta_{0,507}$ (maintained constant) found in the previews question, calculate the condensation temperature $\theta_{K,507}$ which will be established if the HP is not fixed any more (Note: to vary the condensation temperature by step of 1°C, until the criterion of convergence is satisfied).

(2.5 marks)

Question 9

To verify the new mode of operating of the installation is ok or not($\theta_{0,507}$, $\theta_{K,507}$).

(1.5 marks)

Question 10

To give or calculate the followings:

a) refrigerating power
b) heat rejected by the condenser
c) absorbed power
d) COP
e) Volume flow rate of liquid

(2.5 marks)

Question 11

Indicate the effects for the possible modifications to bring to the installation

(1 marks)

END OF QUESTION

Appendix 1: cycles in R-22 and R-507

Cycle R-22

R-22	1	2 = is	3	Dew HP	Bubble HP	4	5	6	Dew LP	7	Bubble LP
p	2.01	13.55	13.55	13.55	13.55	13.55	13.55	2.01	2.01	2.01	2.01
T_{sat}	-25	35	35	35	35	35	35	-25	-25	-25	-25
T	-15	77. 5	77. 5	35	35	32	32		-25	-20	-25
H	401.4	452.3	452.3	415.3	243.1	239.3	239.3	239.3	394.9	398.1	171.3
S	1.81 8	1.81 8	1.82	1.70 5	1.146	1.1340	1.13 4		1.7917	1.8047	0.8908
v	0.1170						0.00086			0.1143	

Cycle R-507

R-507	1	2 = is	3	Dew HP	Bubble HP	4	5	6	Dew LP	7	Bubble LP
p	2.60	16.54	16.54	16.54	16.54	16.54	16.54	2.60	2.60	2.60	2.60
tsat	-25	35	35	35	35	35	35	-25	-25	-25	-25
T	-15	51. 4	51. 4	35	35	32	32		-25	-20	-25
H	357.3	395.9	395.9	375.3	251.6	246.8	246.8	246.8	348.8	353.0	166.5
S	1.64 1	1.64 1	1.64	1.575	1.174	1.15 9	1.15 9		1.60 7	1.624	0.8735
v	0.0773						0.000988			0.0753	

P in bar; T and T_{sat} in °C; H in kJ/kg; S in kJ/(kg.K); v in m^3 / kg

Appendix 2: characteristics of the compressor

Swept volume: 210 m ^{3} / H Overheat: 10K Subcooling: 0K Fluid: R-22

		Temperature of condensation (°C)							
T_{ev} (°C)		33	34	35	36	37	38	39	40
-28	Q_o	45.9	45.1	44.4	43.6	42.9	42.2	41.5	40.8
	W	26.4	26.6	26.8	27.0	27.1	27.3	27.4	27.6
-27	Q_o	48.5	47.7	46.9	46.1	45.4	44.6	43.9	43.2
	W	27.1	27.3	27.5	27.7	27.8	28.0	28.2	28.4
-26	Q_o	51.2	50.4	49.6	48.8	48.0	47.2	46.4	45.7
	W	27.8	28.0	28.2	28.4	28.6	28.8	29.0	29.1
-25	Q_o	54.0	53.1	52.3	51.5	50.7	49.9	49.1	48.3
	W	28.5	28.7	28.9	29.1	29.3	29.5	29.7	29.9
-24	Q_o	56.9	56.0	55.2	54.3	53.5	52.6	51.8	51.0
	W	29.2	29.4	29.6	29.8	30.1	30.3	30.5	30.7
-23	Q_o	59.9	59.0	58.1	57.3	56.4	55.5	54.6	53.8
	W	29.9	30.1	30.3	30.6	30.8	31.0	31.2	31.4
-22	Q_o	63.1	62.2	61.2	60.3	59.4	58.5	57.6	56.7
	W	30.5	30.8	31.0	31.3	31.5	31.8	32.0	32.2
-21	Q_o	66.4	65.4	64.4	63.5	62.5	61.6	60.6	59.7
	W	31.2	31.5	31.7	32.0	32.3	32.5	32.8	33.0
-20	Q_o	69.8	68.8	67.8	66.8	65.8	64.8	63.8	62.8
	W	31.9	32.2	32.4	32.7	33.0	33.2	33.5	33.8
-19	Q_o	73.3	72.3	71.2	70.2	69.1	68.1	67.1	66.1
	W	32.5	32.8	33.1	33.4	33.7	34.0	34.3	34.5
-18	Q_o	77.0	75.9	74.8	73.7	72.6	71.6	70.5	69.5
	W	33.2	33.5	33.8	34.1	34.4	34.7	35.0	35.3
-17	Q_o	80.8	79.6	78.5	77.4	76.3	75.2	74.1	73.0
	W	33.8	34.2	34.5	34.8	35.1	35.4	35.8	36.1

Powers given in kw

		Temperature of condensation (°C)							
T_{ev} (°C)		41	42	43	44	45	46	47	48
-28	Qo	40.1	39.4	38.7	38.0	37.4	36.7	36.0	35.4
	W	27.8	27.9	28.1	28.2	28.4	28.5	28.7	28.8
-27	Q_o	42.4	41.7	41.0	40.3	39.6	38.9	38.3	37.6
	W	28.5	28.7	28.9	29.0	29.2	29.4	29.5	29.7
-26	Q_o	44.9	44.2	43.4	42.7	42.0	41.3	40.6	39.9
	W	29.3	29.5	29.7	29.8	30.0	30.2	30.4	30.5
-25	Q_o	47.5	46.7	45.9	45.2	44.4	43.7	42.9	42.2
	W	30.1	30.3	30.5	30.6	30.8	31.0	31.2	31.4
-24	Q_o	50.2	49.4	48.6	47.8	47.0	46.2	45.4	44.7
	W	30.9	31.1	31.3	31.5	31.7	31.8	32.0	32.2
-23	Q_o	52.9	52.1	51.3	50.4	49.6	48.8	48.0	47.2
	W	31.7	31.9	32.1	32.3	32.5	32.7	32.9	33.1
-22	Q_o	55.8	54.9	54.1	53.2	52.3	51.5	50.7	49.8
	W	32.4	32.7	32.9	33.1	33.3	33.5	33.7	34.0
-21	Q_o	58.8	57.9	57.0	56.1	55.2	54.3	53.4	52.6
	W	33.2	33.5	33.7	33.9	34.2	34.4	34.6	34.8
-20	Q_o	61.9	60.9	60.0	59.1	58.1	57.2	56.3	55.4
	W	34.0	34.3	34.5	34.8	35.0	35.2	35.5	35.7
-19	Q_o	65.1	64.1	63.1	62.2	61.2	60.3	59.3	58.4
	W	34.8	35.1	35.3	35.6	35.8	36.1	36.3	36.6
-18	Q_o	68.4	67.4	66.4	65.4	64.4	63.4	62.4	61.4
	W	35.6	35.9	36.1	36.4	36.7	36.9	37.2	37.5
-17	Q_o	71.9	70.8	69.8	68.7	67.7	66.7	65.6	64.6
	W	36.4	36.7	36.9	37.2	37.5	37.8	38.1	38.3

Powers given in kw

Appendix 3:thermodynamic data of R-22

p	T_{sat}	H_1	v''_1	H_{bubble}	H_4
2.30	-21.7	402.9	0.1033	175.0	171.7
2.40	-20.6	403.4	0.0992	176.3	172.9
2.50	-19.5	403.9	0.0954	177.4	174.1
2.60	-18.5	404.4	0.0920	178.6	175.2
2.70	-17.5	404.8	0.0888	179.7	176.3
2.80	-16.5	405.2	0.0858	180.8	177.4
2.90	-15.6	405.7	0.0830	181.9	178.5
P	T_{sat}	H_1	v''_1	H_{bubble}	H_4
15.74	41.1	426.0	0.0158	251.0	247.1
16.13	42.1	426.3	0.0154	252.4	248.4
16.54	43.1	426.5	0.0150	253.8	249.8
16.95	44.2	426.8	0.0146	255.1	251.2
17.37	45.2	427.0	0.0142	256.5	252.5
17.80	46.2	427.2	0.0139	257.9	253.9

Point 1 and 4 are those of the cycle user in the general diagram

Enthalpy and temperature of isentropic discharge (superheat = 10K)

		Temperature of evaporation (°C)						
HP (bar)		-21.7	-20.6	-19.5	-18.5	-17.5	-16.5	-15.6
15.74	H	454.5	453.8	453.2	452.5	451.9	451.3	450.8
	T	83.2	82.4	81.6	80.9	80.2	79.5	78.9
16.13	H	455.3	454.6	453.9	453.3	452.6	452.1	451.5
	T	84.7	83.8	83.1	82.3	81.6	80.9	80.3
16.54	H	456.5	455.8	455.1	454.5	453.9	453.3	452.7
	T	86.1	85.2	84.5	83.7	83.0	82.3	81.7
16.95	H	457.7	457.0	456.3	455.7	455.1	454.5	453.9
	T	87.5	86.7	85.9	85.1	84.4	83.7	83.1
17.37	H	458.9	458.2	457.5	456.9	456.3	455.7	455.1
	T	88.9	88.1	87.3	86.5	85.8	85.1	84.5
17.8	H	458.7	457.5	456.8	456.2	455.5	454.9	454.4
	T	90.3	89.5	88.7	87.9	87.2	86.5	85.9

P in bar; T and T_{sat} in °C; H in kJ/kg; S in kJ/(kg.K); v in m^3 / kg

Appendix 4:Thermodynamic data of R-507

T	p	H_1	v''_1	H_{dew}	H_{bubble}	H_4
-28.0	2.31	355.5	0.0865	347.1	162.6	158.8
-27.0	2.40	356.1	0.0833	347.6	163.9	160.1
-26.0	2.50	356.7	0.0802	348.2	165.2	161.4
-25.0	2.60	357.3	0.0773	348.8	166.5	162.6
-24.0	2.70	357.9	0.0745	349.3	167.8	163.9
-23.0	2.81	358.5	0.0718	349.9	169.1	165.2
-22.0	2.92	359.1	0.0692	350.4	170.4	166.5
	p	H_1	v''_{bubble}	H_{dew}	H_{bubble}	H_4
33.0	15.74	387.5	0.000994	374.8	248.4	243.7
34.0	16.13	387.8	0.000999	375.0	250.0	245.3
35.0	16.54	388.2	0.001005	375.3	251.6	246.8
36.0	16.95	388.6	0.001010	375.5	253.2	248.4
37.0	17.37	388.9	0.001016	375.7	254.8	250.0
38.0	17.80	389.3	0.001022	375.9	256.5	251.6

Enthalpy and isentropic temperature of repression (overheating aspiration = 10K)

		Temperature of evaporation (°C)						
Tc (°C)		-28.0	-27.0	-26.0	-25.0	-24.0	-23.0	-22.0
33	H	395.6	395.4	395.1	394.9	394.7	394.5	394.3
	T	49.8	49.6	49.4	49.2	49.0	48.8	48.7
34	H	396.1	395.9	395.6	395.4	395.2	395.0	394.8
	T	50.9	50.7	50.5	50.3	50.1	49.9	49.7
35.0	H	396.6	396.4	396.2	395.9	395.7	395.5	395.3
	T	51.9	51.7	51.5	51.4	51.2	51.0	50.8
36.0	H	397.2	396.9	396.7	396.5	396.2	396.0	395.8
	T	53.0	52.8	52.6	52.4	52.2	52.1	51.9
	H	397.7	397.4	397.2	397.0	396.7	396.5	396.3
37.0	T	54.1	53.9	53.7	53.5	53.3	53.1	53.0
38.0		398.2	397.9	397.7	397.5	397.2	397.0	396.8
		55.2	55.0	54.8	54.6	54.4	54.2	54.0

P in bar; T and T_{sat} in °C; H in kJ/kg; S in kJ/(kg.K); v in m^3 / kg