First Semester Examination
2023/2024 Academic Session

February 2024

EME 431 – Refrigeration and Air Conditioning
(Penyejukan dan Penyamanan Udara)

Duration: 2 hours
(Masa: 2 Jam)

Please check that this examination paper consists of NINE (9) pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEMBILAN (9) muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions: Answer ALL **FOUR (4)** questions.

*[**Arahan**: Jawab **EMPAT (4)** soalan]*

Appendices:

- R410A p-h Diagram
- Psychometric Charts
- Table of Heat Transfer Coefficient for Glass and Roof

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1. (a) Sketch the following refrigeration cycles on p-h diagram for each cycle in the following questions and label the given numbers on the p-h diagram.

(i) Two evaporators and one compressor (as shown in Figure 1(a) (i))

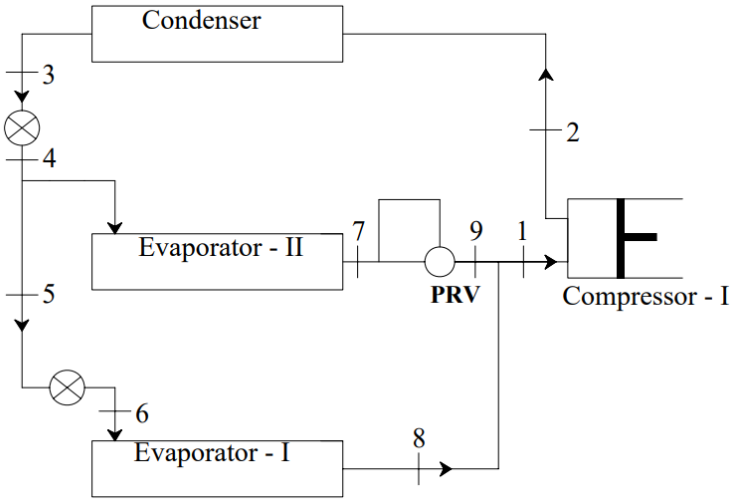

Figure 1(a) (i): Two evaporators and one compressor

(15 Marks)

(ii) Two evaporators and two compressors (as shown in Figure 1 (a) (ii))

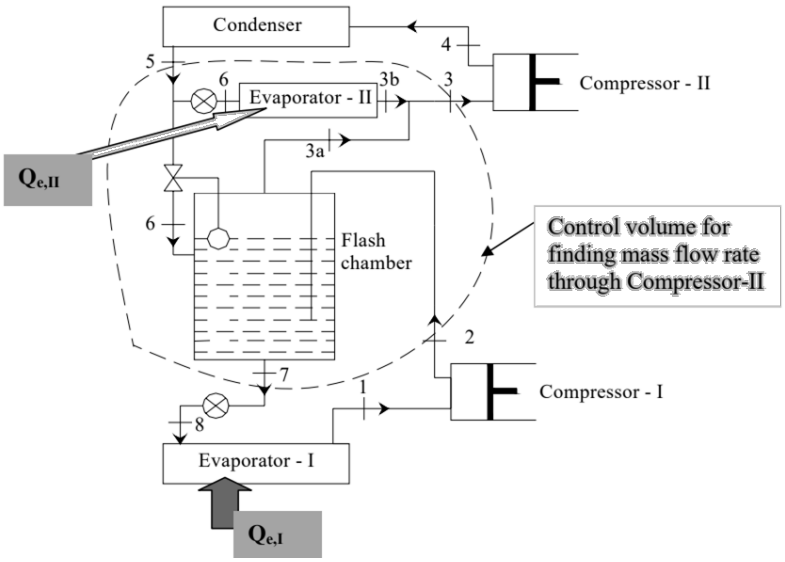

Figure 1 (a) (ii): Two evaporators and two compressors

(15 Marks)

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(b) A freezer for cold storage using vapour compression cycle and refrigerant R410a operates with condensing temperature of 38°C and evaporator temperature of -25°C. If the mass flow rate of the refrigerant is 0.45 kg/s,

Calculate:

(i) refrigerating effect

(30 Marks)

(ii) cooling capacity

(10 Marks)

(iii) power required by compressor

(20 Marks)

(iv) coefficient of performance (COP) of the system

(10 Marks)

2. (a) With the aid of a diagram, describe the operation of an evaporative cooling system.

(30 Marks)

(b) An evaporative cooling system was designed for an alfresco restaurant, when the outdoor temperature is 35°C and relative humidity of 55%.

(i) What is the achievable minimum cooling temperature?

(10 Marks)

(ii) Plot the cooling process (i) on a psychrometric chart and **submit the chart with your answer script.**

(10 Marks)

(iii) If the efficiency of the designed machine is 85%, calculate the final temperature and relative humidity of the output air?

(30 Marks)

(c) Identify the working fluids for both refrigerators in Table 2(c).

Table 2(c): Einstein-Szilard refrigerator vs Platen-Munters refrigerator

	Einstein-Szilard refrigerator	**Platen-Munters refrigerator**
Refrigerant		
Absorbent		Water
Inert gas	Ammonia	

(20 Marks)

...4/-

3. (a) Describe **THREE (3)** environmental factors that can affect thermal comfort in air-conditioned space.

(30 Marks)

(b) An Archival storage room of 5m height is shown in Figure 3(b). Use Table 3 (b) and data tables in the Appendix for your calculations. Make all the necessary assumptions and consider the following values at the peak load:

(i) Coefficient of overall heat transfer for walls is U= 0.64W/m^{2}K.
(ii) Windows total area of 3m^2 located at the north-west wall with double glazed tinted glass.
(iii) Roof is a heavy-weight 100mm concrete with 50mm insulation and no suspension ceiling.
(iv) Three employees.
(v) Room equipment: computers, monitors, printers, etc. (consider suitable cooling load factor).
(vi) Lighting requirement 30 W/m^2 of floor area (Fluorescent lamps).

Calculate the peak room heat gain and sensible heat factor (SHF).

(70 Marks)

Table 3 (b)

	Corrected CLTD for walls/windows (K)	**MSHGF (W/m^2)**
N	24	117
NE	21	492
E	20	760
SE	22	581
S	23	174
SW	24	581
W	24	760
NW	24	492

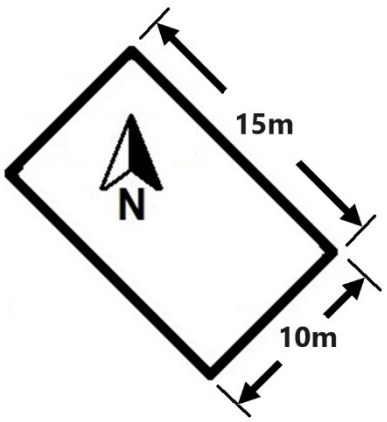

Figure 3 (b)

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4. (a) For an air conditioning ducting system, with given air flow rate and velocity in the main duct, describe the steps and formulations involved in calculating the duct system size, pressure drop through the system and the power of the blower.

(30 Marks)

(b) During the design of an air conditioning system, two systems were proposed as shown in Figure 4(b). System 1 includes adiabatic dehumidifier desiccant which consumes 3kW for each kg of absorbed water. System 2 includes a compression refrigeration coil with dew point of 5ºC. Assume air flow of 1kg/s, entering the systems at 27ºC and RH 60%, while room inlet temperature is 20ºC and RH 55%.

(i) Draw the processes for both System 1 and System 2 on the attached psychometric chart and **submit the chart with your answer script.**

(10 Marks)

Calculate:

(ii) Efficiency of the compression refrigeration coil in System 2.

(20 Marks)

(iii) Total power consumption for each system.

(40 Marks)

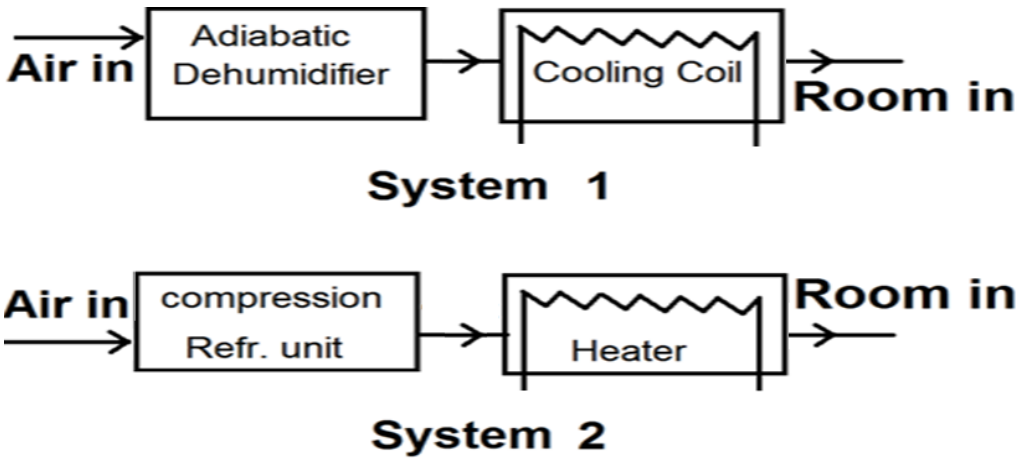

Figure 4 (b)

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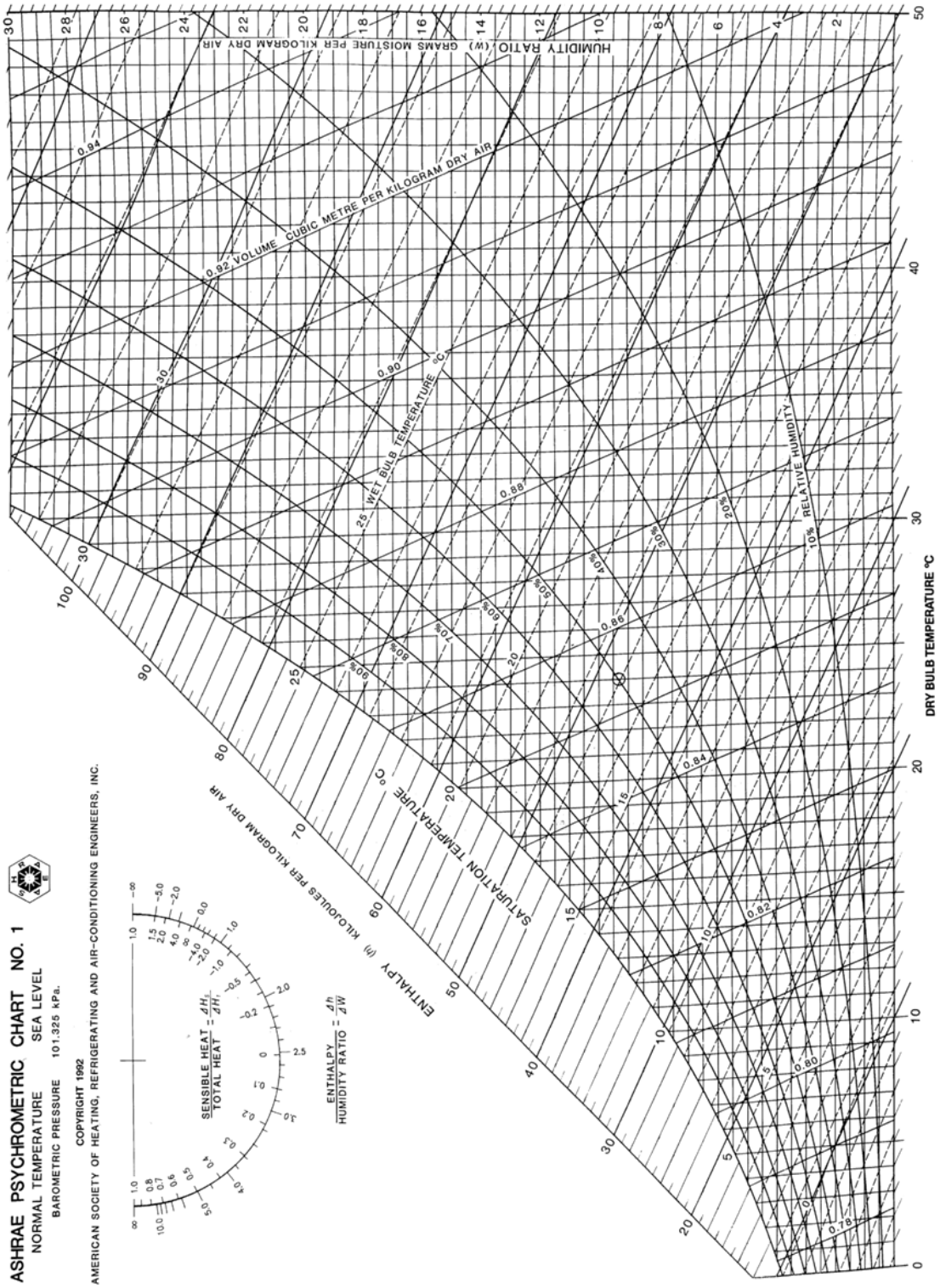
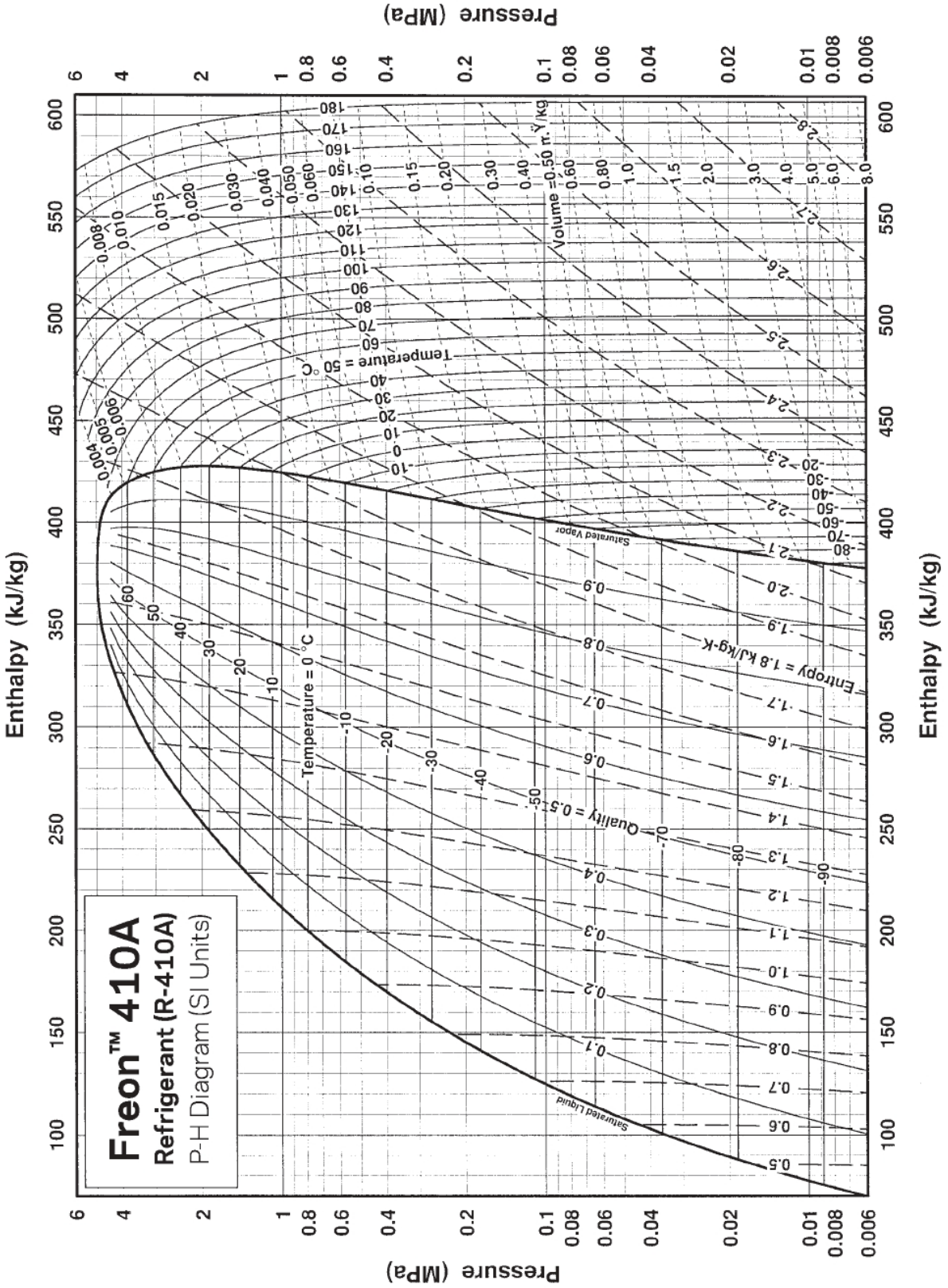
APPENDIX

For Question 2 (b)




Freon™ 410A
Refrigerant (R-410A)
P-H Diagram (SI Units)
Pressure (MPa)
Enthalpy (kJ/kg)
Saturated Liquid
Saturated Vapor
Quality = 0.5
Temperature = 0 °C
Temperature = 50 °C
Volume = 0.50 m³/kg
Entropy = 1.8 kJ/kg-K

The window glass types

Glass Types		U-value (W/m^2K)	Shading coefficient
Single	Clear	6.17	0.95
	Tinted	6.17	0.71
	Reflective	5.11	0.29
	Low-e	4.27	0.84
Double	Clear	2.79	0.89
	Tint	2.79	0.71
	Reflective	2.35	0.20
	Low-e	1.99	0.85

Corrected CLTD of different types of roofs without suspention ceiling

Roof no.	Description of construction	Corrected CLTD	U-value $W/m^2.K$
1	Steel sheet with 25 mm insulation (or 50 mm)	44	1.209 (0.704)
2	25 mm wood with 25 mm insulation	41	0.965
3	100 mm l.w. concrete	40	1.209
4	50 mm h.w. concrete with 25 mm (or 50 mm) insulation	37	1.170 (0.693)
5	25 mm wood with 50 mm insulation	36	0.619
6	150 mm l.w. concrete	36	0.897
7	60 mm wood with 25 mm insulation	31	0.738
8	200 mm l.w. concrete	30	0.715
9	100 mm h.w. concrete with 25 mm (or 50 mm) insulation	30	1.136 (0.681)
10	60 mm wood will 50 mm insulation	29	0.528
11	Roof terrace system	26	0.602
12	150 mm h.w. concrete with 25 mm (or 50 mm) insulation	25	(1.090) (0.664)
13	100 mm wood with 25 mm insulation (or 50 mm)	24	0.602 (0.443)

For Question 4(b)