UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2014

Module Number: ME5314 **Module Name: Refrigeration and Air-conditioning**

[Three Hours]

[Answer **all questions.** Each question carries ten marks]

Q1 Write short answers to the following. Provide neat sketches and diagrams whenever possible.

a) Plenty of waste heat is available from an exhaust of a steam power plant. Explain, how you are going to utilize this heat to run an absorption refrigerator system?

b) A vapour compression refrigerator is not giving the cool as before. State possible causes for this performance reduction and how are you going to verify them.

c) While the outdoors is at 5°C, a house is to be maintained at 20°C using a heat pump. Assume that low-cost geothermal energy is available at 10°C. How are you going to use this geothermal energy to increase the COP of the heat pump?

d) Pressure drop occurs when a liquid flows through narrow tubes. Draw a no-sub-cool no-superheat refrigeration cycle on a *P-h* diagram showing the pressure drop in the evaporator and the condenser.

e) Explain the operating principle behind the *Thermoelectric cooler*.

[10 marks]

Q2 A 500-ton (1760kW) single-stage centrifugal vapor compression system uses HCFC-22 (R22) as the refrigerant. The vapor refrigerant enters the compressor at dry saturated state. The compression process is assumed to be isentropic. Hot gas is discharged to the condenser and condensed at a temperature of 35°C. The saturated liquid refrigerant then flows through a throttling device and evaporates at a temperature of 1.7°C. Show the cycle on *P-h* diagram and calculate,

a) the refrigeration effect,

b) mass flow rate of the refrigerant,

c) work input to the compressor

d) coefficient of performance of this refrigeration cycle,

Recalculate the COP and the energy saved in compressor work input if the refrigerant is sub-cooled to a temperature of 32.2°C. Show the cycle on a *P-h* diagram.

[10 marks]

Q3 Figure Q3 shows Ammonia-water vapour-absorption refrigeration system which has a refrigeration capacity of 100 TR. The various state properties of the system are given in Table Q3. Calculate,

a) the mass flow rate of solution through the evaporator, and, mass flow rates of strong solution and weak solution,

b) heat transfer rates at condenser, absorber and generator,

c) the system COP.

[10 marks]

Q4 a) Explain the factors governing the Bypass Factor (BF) of a cooling and dehumidifying coil.

[2.5 Marks]

b) What do you understand by "dehumidified air quantity" and how this quantity is estimated with minimum error?

[2.5 Marks]

c) Explain coil Apparatus Dew Point (ADP) and the effect of it on the performance of an air-conditioning system.

[2.5 Marks]

d) State the advantages of mixing of re-circulated air and fresh air in an air-conditioning system.

[2.5 Marks]

Q5 In an air conditioning plant of a theater, fresh air is cooled by means of a coil with a Bypass Factor (BF) of 0.15. The cooled fresh are is then mixed with an equal mass of air re-circulated from the theater and mixture is supplied to the theater. Under the peak outside air condition, of 38° C Dry Bulb Temperature (DBT) and 26°C Wet Bulb Temperature (WBT), the Room Sensible Heat (RSH) and the Room Latent Heat (RLH) gain of the theater are 4.7 kW and 2.2 kW, respectively. The air in the theater is to be maintained at 26° C DBT under these conditions. If the cooling coil temperature is 11°C. Using the Psychrometric Chart, calculate,

i) the room ADP,

ii) the relative Humidity (RH) in the conditioned space

iii) the quantity of fresh air entering the cooler

iv) the cooling capacity of the coil.

[10 marks]

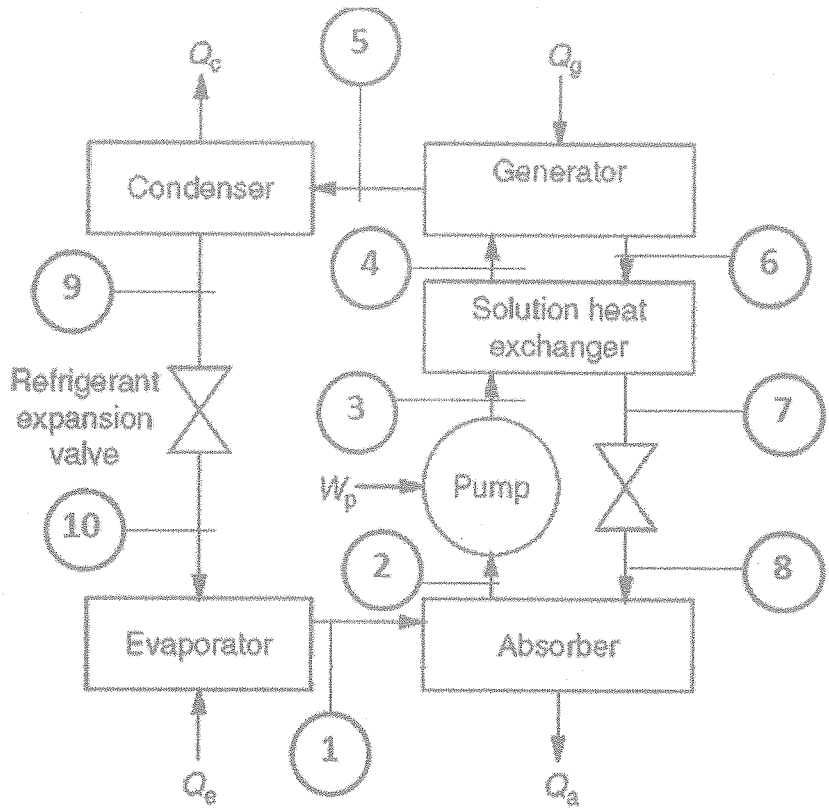
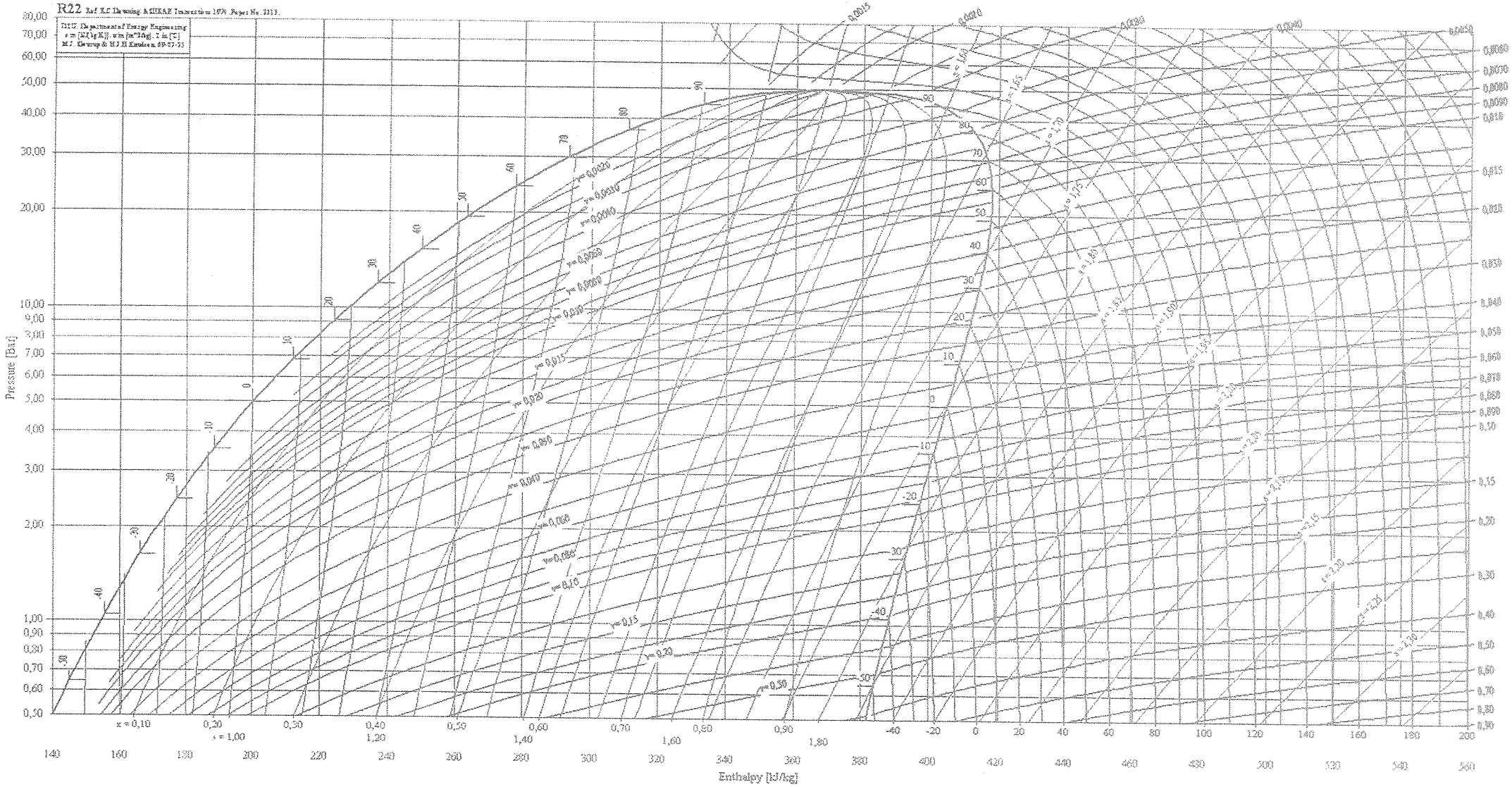


Figure Q3

Table Q3

State point	P, bar	T, °C	Concentration (X), kg of NH_3/kg of solution	Enthalpy, kJ/kg
1	2.04	13.9	0.996	1442.3
2	2.04	26.1	0.408	-58.2
3	13.61	26.1	0.408	-56.8
4	13.61	93.3	0.408	253.6
5	13.61	54.4	0.996	1512.1
6	13.61	115.6	0.298	369.9
7	13.61	36.1	0.298	.....
8	2.04	36.1	0.298	.....
9	13.61	36.1	0.996	344.3
10	2.04	-17.8	0.996	.....


R22 Ref: K.F Downing ASHRAE Transactions 1976 Paper No. 2313.
DTU, Department of Energy Engineering
s = [kJ/kgK] v in [m^3/kg] T in [°C]
M.J. Skovrup & H.J.H Knudsen, 09-07-23
Pressure [Bar]
Enthalpy [kJ/kg]