UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2015

Module Number: ME5304 **Module Name: Refrigeration and Air Conditioning**

[Three Hours]

[Answer **all questions.** R-22 property charts, LiBr-water charts, Steam tables, and Psychrometric charts are provided]

Q1 Write short answers to the following

a) Consider a solar water heater that provides plenty of hot water at high temperature. Using a sketch, explain how you are going to utilize this heat to run an absorption refrigerator system.

[1 Mark]

b) 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

[1 Mark]

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?

[1 Mark]

d) Compressor is the electricity consuming device in a refrigerator. How would the compressor react when you reduce the set temperature of the refrigerator?

[1 Mark]

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

[1 Mark]

Q2 a) List a few energy efficiency improvement options in a refrigeration plant.

[2 Marks]

b) Figure Q2 shows a 1760 kW two-stage compound vapor compression system with a flash chamber that uses HCFC-22 (R22) as the refrigerant. Evaporating and condensing temperatures are 1.7°C and 35°C respectively. Refrigerant vapour enters the low-stage compressor at dry saturated state, and the subcooled liquid refrigerant leaves the condenser at a temperature of 32.2°C. Both compression processes are assumed to be isentropic. Determine,

i. The refrigeration effect per kg of refrigerant flowing through the condenser.

[3 Marks]

ii. The total work input to the compressor

[3 Marks]

iii. The coefficient of performance of the system

[2 Marks]

c) Consider a single-stage vapor compression system of 1760 kW, that operates at similar evaporation and condensing pressures, similar compressor inlet and condenser outlet conditions, and has an isentropic compressor. Calculate the percentage saving in energy consumption compared with the two-stage system in part (b).

[5 Marks]

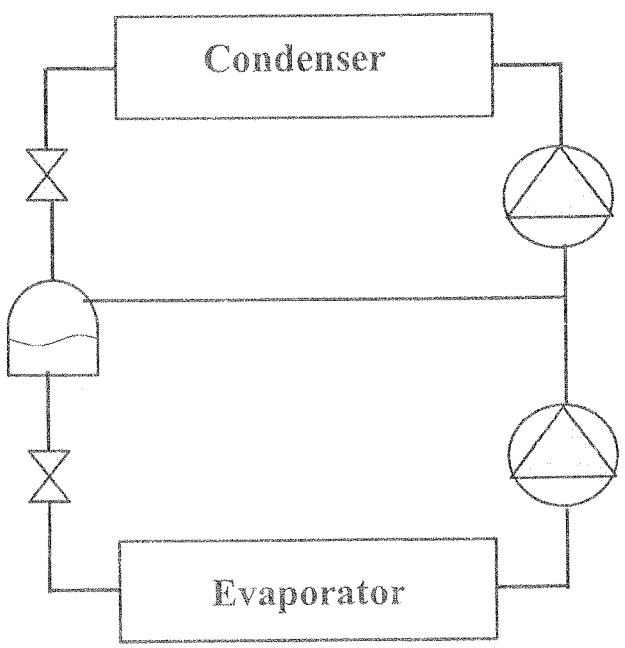


Figure Q2

Q3 a)

Briefly describe how does a vapour absorption refrigeration system operate.

[2 Marks]

b) i. A LiBr-water vapour absorption refrigerator operates at following temperatures; Generator - 100°C, Absorber - 30°C, Condenser - 40°C and Evaporator - 10°C. The pump delivers 0.6kg/s of solution. Assuming there is no heat exchanger placed between the generator and the absorber, calculate the COP of the refrigerator.

[7 Marks]

ii. If a heat exchanger is inserted between the generator and the absorber, state would happen to the COP giving reasons.

[1 Marks]

Q4 a) What are the benefits of using an air conditioning system in an office space?

[2 Marks]

b) What are the important factors that should be considered in selecting a suitable air conditioning system to a cinema hall?

[2 Marks]

c) Explain five essential components of a chilled water type air conditioning system.

[2 Marks]

d) Explain difference between Room Sensible Heat Factor (RSHF) and Grand Sensible Heat Factor (GSHF).

[2 Marks]

Q5 In a pharmaceutical company, an air conditioning system is used to maintain conditions of air inside the process room at 27° C Dry Bulb Temperature (DBT) and 21° C Wet Bulb Temperature (WBT). The heat load survey conducted for the process room has indicated that the total heat gain is 80 kW and it contains 23.5 kW of latent heat gain. In the air conditioning system, outside air at 38°C DBT and 27 °C WBT is cooled by means of a cooling coil and the cooled fresh air is then mixed with the recirculated air from the process room. The recirculated air quantity from the room is approximately equal to the 70% of the total air quantity required for the room. Considering the block diagram of the air conditioning system as shown in Figure Q5 and taking the cooling coil temperature as 15 °C, determine,

i) Condition of air before mixing with recirculated air

ii) Condition of air entering the room

iii) Room Sensible Heat Factor (RSHF)

iv) Bypass Factor (BF) of the cooling coil

v) The quantity of fresh air entering the cooling coil

vi) The capacity of the cooling coil.

[12 Marks]

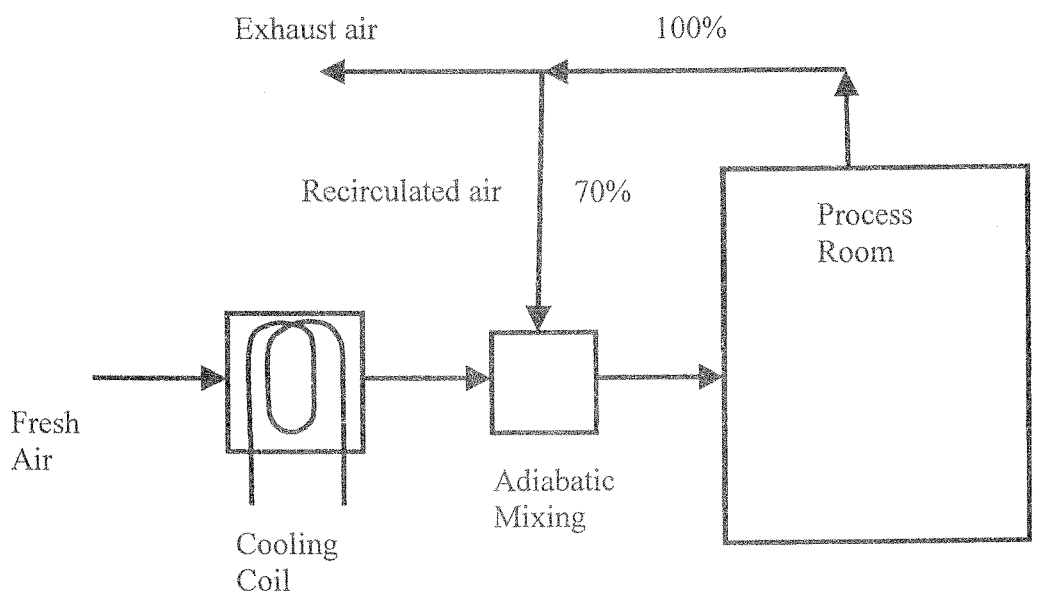
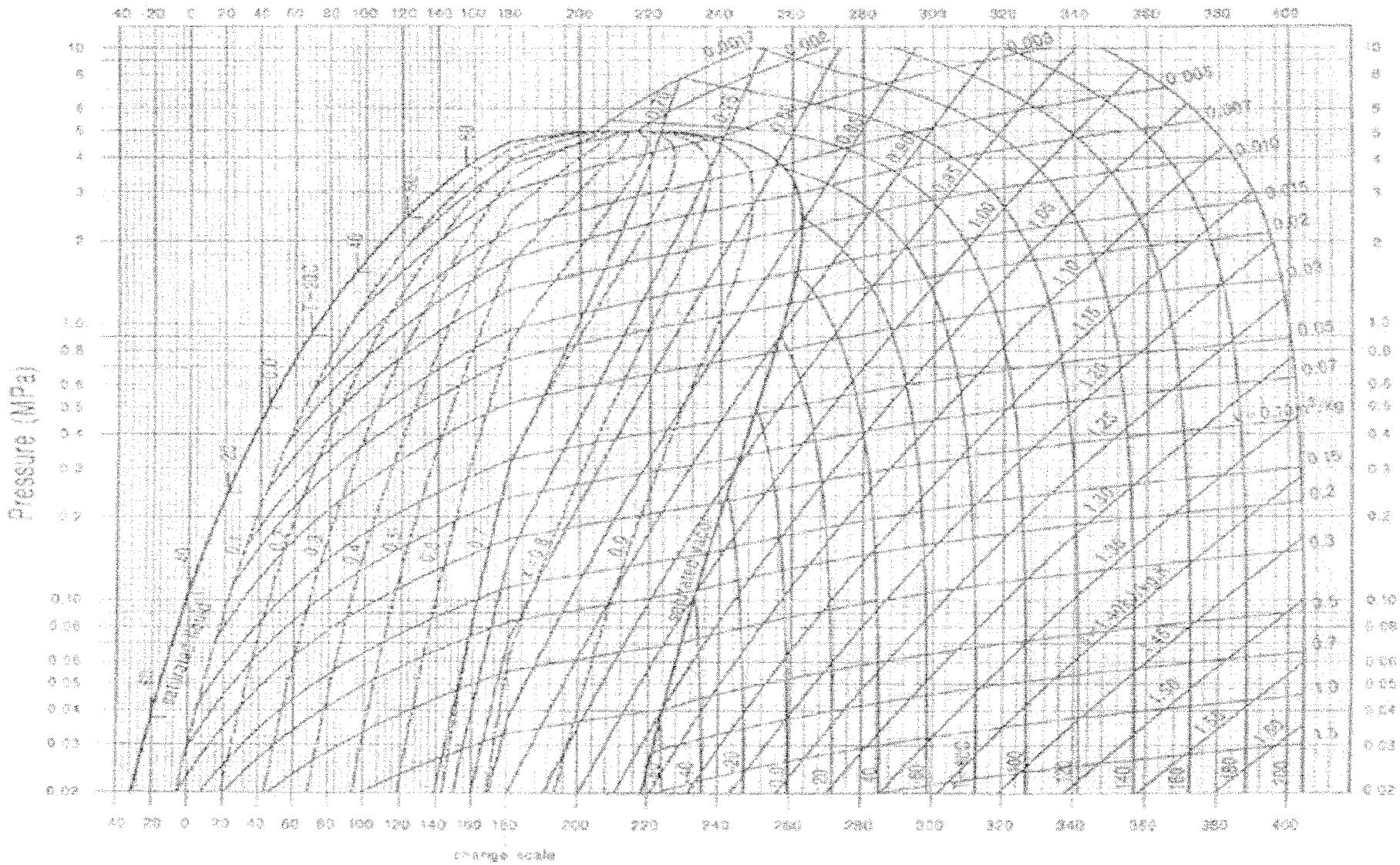
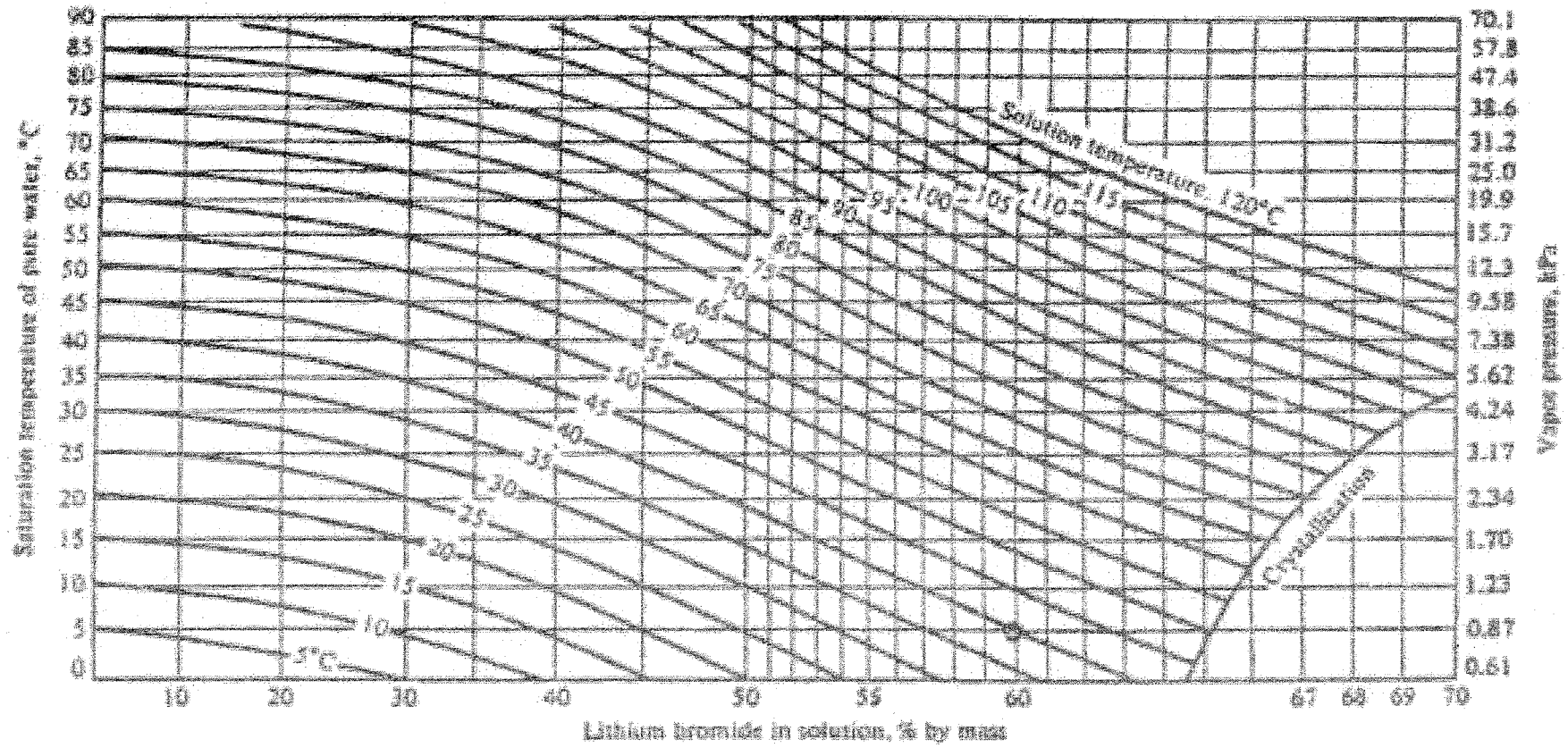


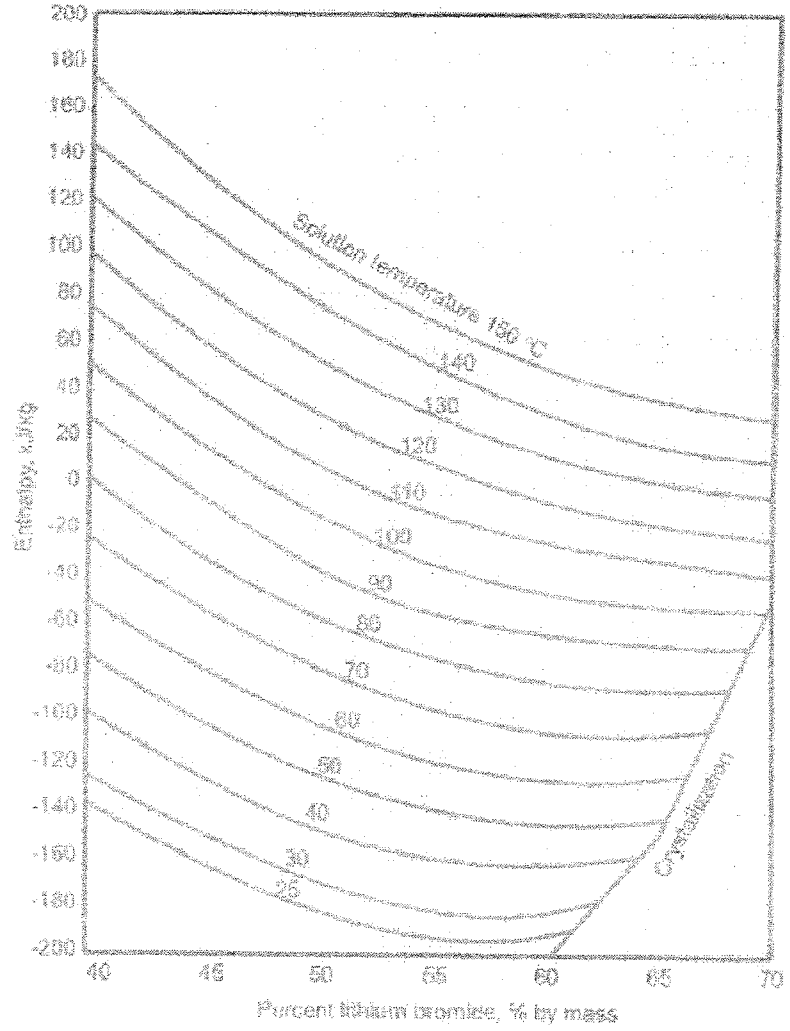
Figure Q5

Pressure-Enthalpy Diagram for R22





P-t-x diagram for water-LiBr system



h-t-x diagram for water-LiBr system