UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESI 2011/2012

COURSE NAME	:	TERMODINAMIK II
COURSE CODE	:	BDA 30403/3043
PROGRAMME	:	BACHELOR OF MECHANICAL ENGINEERING WITH HONOURS
EXAMINATION DATE	:	JUNE 2012
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER FOUR (4) QUESTIONS ONLY FROM SIX (6) QUESTIONS

THIS PAPER CONSISTS OF EIGHT (8) PRINTED PAGES

Q1 (a) A steam power plant operating on the Carnot cycle working between the pressure of 0.05 bar and 53 bar. Water enters the boiler as saturated vapor and it leaves the boiler in a state of saturation. Determine the thermal efficiency of the plant and draw the cycle on a T-s diagram.

(7 marks)

(b) **Figure Q1** shows a steam power plant operating on the Rankine cycle. The plant supplies power to two generators. Saturates water enters the feed water pump at a pressure of 1.3 bar and leaves at a pressure of 20 bar. Steam has a maximum temperature of 330°C and expands in low-pressure turbine to the condenser pressure. Isentropic efficiency of the high pressure turbine and low pressure are 0.9 and 0.85 respectively. If the steam mass flow rate is 400kg/h, determine:

(i) Describes the thermodynamics process on T-s diagram
(ii) The power of the two turbines;
(iii) The work ratio;
(iv) The thermal efficiency of the plant;
(v) The specific steam consumption;
(vi) The power of the plants if mechanical efficiency is 0.8.

(18 marks)

Q2 (a) How does regeneration affect the efficiency of a Brayton cycle, and how does it accomplish it?

(3 marks)

(b) A gas-turbine engine with regeneration operates with two stages of compression and two stages of expansion. The pressure ratio across each stage of the compressor and turbine is 3.5. The air enters each stage of the compressor at 300 K and each stage of the turbine at 1200 K. The compressor and turbine efficiencies are 78 and 86 percent, respectively, and the effectiveness of the regenerator is 72 percent.

(i) Show the cycle on *T-s* diagram.
(ii) Determine the back work ratio
(iii) The thermal efficiency of the cycle
(iv) If the pressure ratio is doubled without changing the minimum and maximum temperatures in the cycle. Compare the thermal efficiency of the cycle as a result of this modification. Explain the result.

Take, $c_p = 1.005$ kJ/kgK and $k = 1.4$

(22 marks)

Q3 (a) What is clearance volume? Explain the effect of clearance volume on the performance of a reciprocating compressor.

(4 marks)

(b) A single acting reciprocating compressor runs at 700 rev/min. It compresses air in two-stages to 80 bar from an induction pressure of 1 bar with an ideal intermediate pressure and complete intercooling. The free air delivery is 0.06 m^3/s at the pressure 1.013 bar and 20°C. The clearance volume is 3 % of the swept volume in each cylinder. The index of the compression and re-expansion is 1.3 for both cylinders. The temperature at the end of the induction stroke in each cylinder is 30°C. The mechanical efficiency of the compressor is 85 %. Determine the following:

(i) Sketch the compression processes on the p-V diagram
(ii) The indicated power required
(iii) The saving in power over single-stage compression between the same pressure
(iv) The swept volume at each stage
(v) The required power output of the drive motor.

For air, take R=0.287 kJ/kgK and c_p=1.005 kJ/kgK.

(21 marks)

Q4 A two-stage cascade refrigeration system as shown in **Figure Q4**, operates between the pressure limits of 1.4 MPa and 200 kPa with refrigerant R-134a as the working fluid. Heat rejection from the lower cycle to the upper cycle takes place in an adiabatic counterflow heat exchanger where the pressure in the upper and lower cycles are 0.4 MPa and 0.6 MPa, respectively.
In both cycles, the refrigerant is a saturated liquid at the condenser exit and a saturated vapor at the compressor inlet. The isentropic efficiency of each compressor is 85 %. The mass flow rate of the refrigerant through the lower cycle is 12.0 kg/min.

(i) Describe the cooling processes using p – h diagram.
(ii) Determine the enthalpy of the refrigerant at every state.
(iii) Calculate the mass flow rate of the refrigerant through the upper cycle.
(iv) What is the rate of heat removal from the refrigerated space (the refrigerating capacity)?
(v) Evaluate the Coefficient of Performance (COP) for the refrigeration system.

(25 marks)

Q5 (a) In an Otto cycle, the minimum air temperature is 15°C and the maximum air temperature is 1400°C. The heat supplied is 800kJ/kg. Determine,

(i) Calculate the compression ratio
(ii) thermal efficiency
(iii) Calculate the ratio of the maximum pressure to minimum pressure for the cycle.

(10 marks)

(b) A 4-stroke petrol engine with four cylinders uses an indicator to determine the indicated mean effective pressure. Spring constant of the indicators is 0.8 bar / mm. Area and the length of the indicator diagram are 200 mm^2 and 30 mm respectively. Cross sectional area of the piston and the stroke of the engine cylinders are 100 cm^2 and 12 cm respectively. The engine is connected to a hydraulic Dynamometer for performance testing. At an average speed of 3000rpm engine, load brake and brake arms are 280 N and 60 cm respectively. If the mass flow rate of fuel used and the lower caloric value (LCV) are 0.0014 kg / s and 44.3 MJ / kg respectively, determine:

(i) the indicated power engine;
(ii) The power of friction;
(iii) The mechanical efficiency;
(iv) The brake thermal efficiency and
(v) The specific fuel consumption

(15 marks)

Q6. (a) The air at 25 °C and 100 kPa in a 150 m^3 room has a relative humidity of 60%. The air is cooled below the dew point to 10°C. Estimate the amount of water vapor that will condense.

(5 marks)

(b) A cooling tower of a small process plant as illustrated in **Figure Q6**, is designed to cool 5.0 kg of water per second. The inlet temperature of the warm water is 40 $^{\circ}$C. The motor-driven fan induces 12 m^3/s of air through the tower and the power absorbed is 6.0 kW. The air entering the tower is at 25 $^{\circ}$C, and has a relative humidity of 60 %. The air leaving the tower is saturated at a temperature of 30 $^{\circ}$C. The pressure throughout the tower is constant at 101.3 kPa, and the makeup water is added outside the tower.

(i) Calculate the humidity ratio at the air inlet.
(ii) What is the amount of the mass flow rate of the makeup water required?
(iii) Determine the final temperature of the water leaving the tower.

(20 marks)

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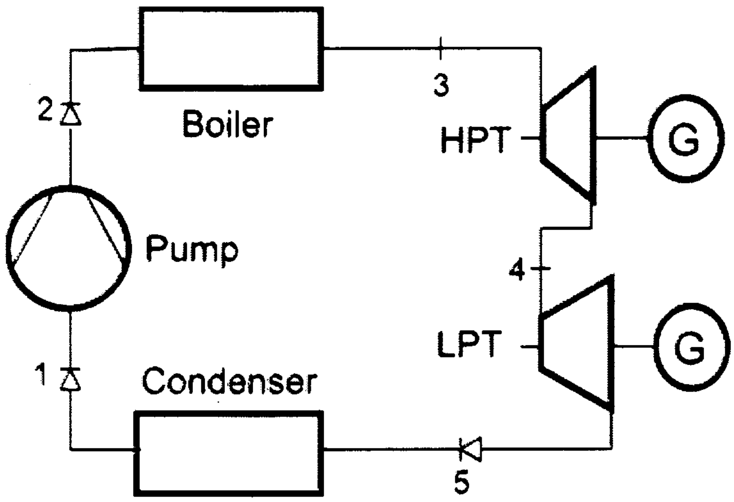

Figure Q1

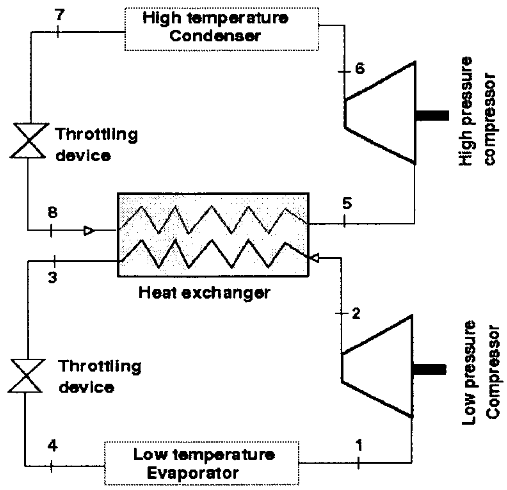

Figure Q4

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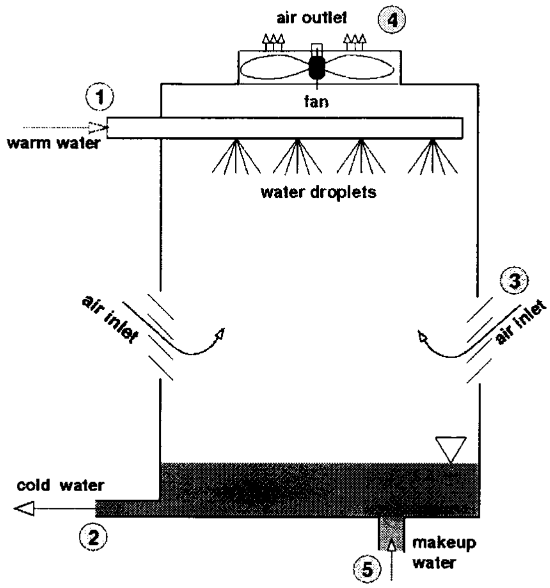

Figure Q6

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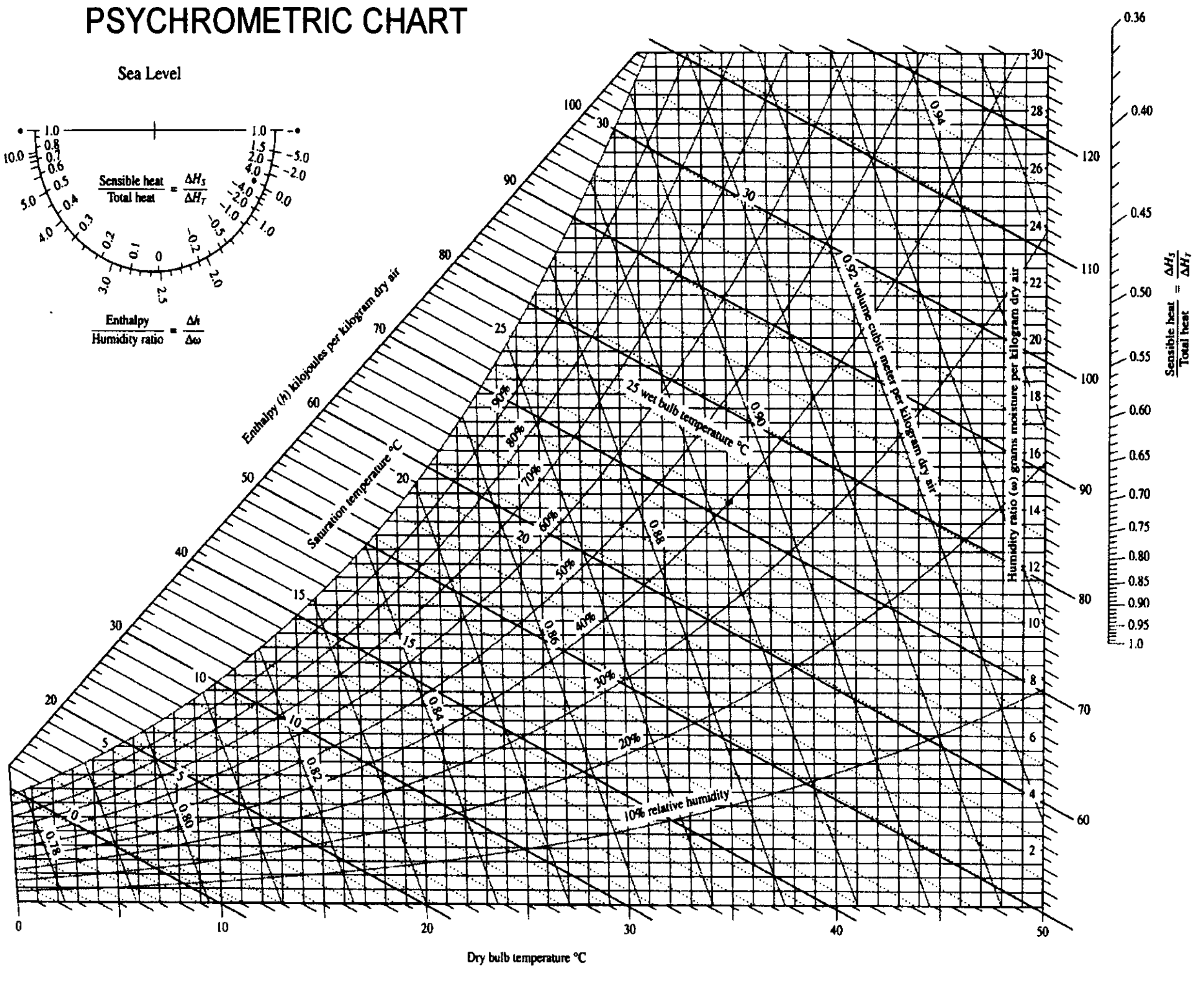

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p-h diagram

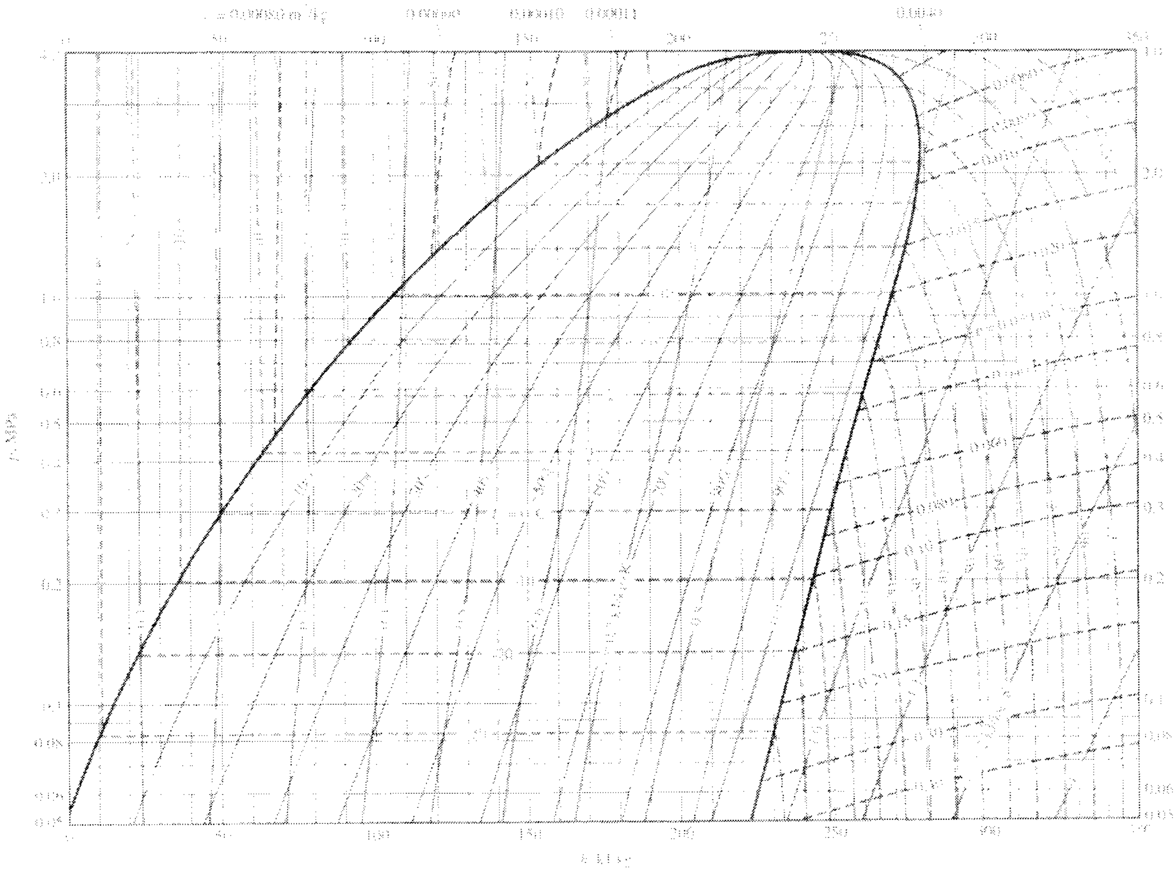

Chart A-11 R134a *ph* diagram. (*Source:* Based on *Thermodynamic Properties of HFC-134a (1,1,1,2-tetrafluoroethane)*. DuPont Company, Wilmington, Delaware, 1993, with permission.)