UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	THERMODYNAMICS II
COURSE CODE	:	BDA 30403
PROGRAMME	:	3 BDD
EXAMINATION DATE	:	DECEMBER 2019/JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS **ONLY**

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) Explain the differences between open and closed feedwater heater systems. Please emphasize the effectiveness of each system in improving the performance of a Rankine based steam power plant.

(3 marks)

(b) A steam power plant operates on an ideal regenerative Rankine cycle. Its turbine receives steam at 6 MPa and 450°C. The steam is then condensed in the condenser at 20 kPa. The power plant uses an open feedwater heater, which utilises steam extracted from the turbine at 0.8 MPa. Water leaves the feedwater heater as a saturated liquid.

(i) Show the cycle on a T-s diagram; and
(ii) Determine the heat supplied per kilogram of steam flowing through the boiler (kJ/kg).

(17 marks)

Q2 (a) Define the effectiveness of a regenerator used in gas-turbine cycles.

(2 marks)

(b) A gas turbine power plant is developed to supply power to a factory as shown in **Figure Q2 (b).** The temperature and pressure of the air at the inlet are 273K and 100 kPa. The compressor is driven by high pressure turbine and low pressure turbine is coupled to the generator directly. The maximum cycle temperature is 1500 K. Pressure ratio of the compressor is 8:1. Isentropic efficiency of the compressor is 80%. Isentropic efficiency of high pressure turbine is 85% and isentropic efficiency of the low pressure turbine is 83%. Determine;

(i) the temperature and pressure at the exit of high pressure turbine;
(ii) the power developed by the unit in kW if the air flow through the compressor is 10 kg/s;
(iii) the thermal efficiency; and
(iv) back work ratio

(18 marks)

Q3 (a) With an aided of appropriate sketch, explain working cycle of reciprocating compressor.

(5 marks)

(b) A single stage, single-acting compressor delivers 3 m^3/min of air measured at pressure of 1.014 bar and 23°C. During induction, pressure and temperature or air is 0.98 bar and 43°C respectively. Delivery pressure is 6.5 bar and crank speed is 358 rpm. The clearance volume is 5% of swept volume and the compression index is 1.3. Determine;

(i) the indicated power; and
(ii) the volumetric efficiency;

(15 marks)

Q4 (a) Differentiate the actual vapor-compression refrigeration cycle and the two-stage cascade refrigeration cycle. Use appropriate sketches for the explanation.

(5 marks)

(b) Refrigerant-134a enters the compressor of a refrigerator as superheated vapor at 0.20 MPa and -5 °C at a rate of 0.07 kg/s and leaves at 1.2 MPa and 70°C. The refrigerant is cooled in the condenser to 44 °C and 1.15 MPa, and it is throttled to 0.21 MPa. Show the cycle on a T-s diagram with respect to saturation lines, and determine;

(i) rate of heat removal from the refrigerated space and power input to the compressor;
(ii) the Isentropic efficiency of the compressor and
(iii) COP of the refrigerator.

(15 marks)

Q5 (a) Describe the purpose of using the wet cooling towers.

(2 marks)

(b) Water enters a cooling tower at 35°C and at a rate of 1.4 kg/s, and leaves at 25°C. Humid air enters this tower at 1 atmosphere and 17°C with a relative humidity of 30 percent and leaves at 22°C with relative humidity of 80 percent. Determine the mass flow rate of dry air through this tower.

(18 marks)

Q6 (a) Explain five processes that make up the air-standard dual cycle.

(5 marks)

(b) The compression ratio of an air-standard dual cycle is 12 and a cutoff ratio of 1.3. The pressure ratio during the constant-volume heat addition process is 1.5. This cycle is operated at 100 kPa and 20°C at the beginning of the compression. By using the constant specific heats at room temperature, determine :

(i) the maximum gas pressure;
(ii) the maximum gas temperature;
(iii) amount of heat added; and
(iv) thermal efficiency.

(15 marks)

- END OF QUESTION –

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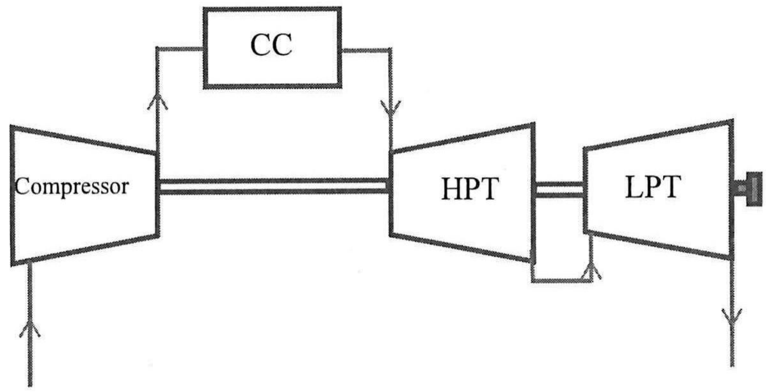

Figure Q2 (b)

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List of Formula

$$bwr = \frac{w_{pump}}{w_{turbine}}$$

$$\eta_P = \frac{w_s}{w_a}$$

$$\eta_T = \frac{w_a}{w_s}$$

$$\eta_{th} = \frac{w_{net}}{q_{in}}$$

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{(k-1)}{k}} = \left(\frac{P_3}{P_4}\right)^{\frac{(k-1)}{k}} = \frac{T_3}{T_4}$$

$$\epsilon = \frac{q_{regen_{actual}}}{q_{regen_{maximum}}}$$

$$IP = \frac{n}{n-1}\dot{m}R(T_2 - T_1)$$

$$Isothermal\,Power = \dot{m}RT\ln\frac{P_2}{P_1}$$

$$V_{in} = V_a - V_d$$

$$\eta_v = \frac{V_a - V_d}{V_s}$$

$$V_s = V_a - V_c$$

$$\frac{V_s}{V_c} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{n}}$$

$$COP_R = \frac{q_L}{w_{net,in}}$$

$$P = P_a + P_v$$

$$h_{dry\ air} = C_p T$$

$$\phi = \frac{\omega P}{(0.622+\omega)P_g}$$

$$h = h_a + \omega h_g$$

$$\dot{Q}_{in} = \dot{m}_a(h_2 - h_1)$$

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$$\dot{Q}_{out} = \dot{m}_a(h_1 - h_2) - \dot{m}_w h_w$$

$$\dot{m}_{make\ up} = \dot{m}_a(\omega_2 - \omega_1) = \dot{m}_3 - \dot{m}_4$$

$$\dot{m}_3 h_3 = \dot{m}_a(h_2 - h_1) + (\dot{m}_3 - \dot{m}_{make\ up})h_4$$

$$\dot{m}_a = \frac{\dot{m}_3(h_3 - h_4)}{(h_2 - h_1) - (\omega_2 - \omega_1)h_4}$$

$$MEP = \frac{w_{net}}{V_s} = \frac{W_{net}}{V_{max} - V_{min}}$$

$$Q_{in} = mC_v(T_3 - T_2)$$

$$Q_{out} = mC_v(T_4 - T_1)$$

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{v_1}{v_2} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{k}}$$

$$\frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{k-1}$$

$$r_c = \frac{P_3}{P_2} = \frac{T_3}{T_2} \quad cutoff\ ratio$$

$$r_v = \frac{v_1}{v_2} = \frac{V_1}{V_2}$$

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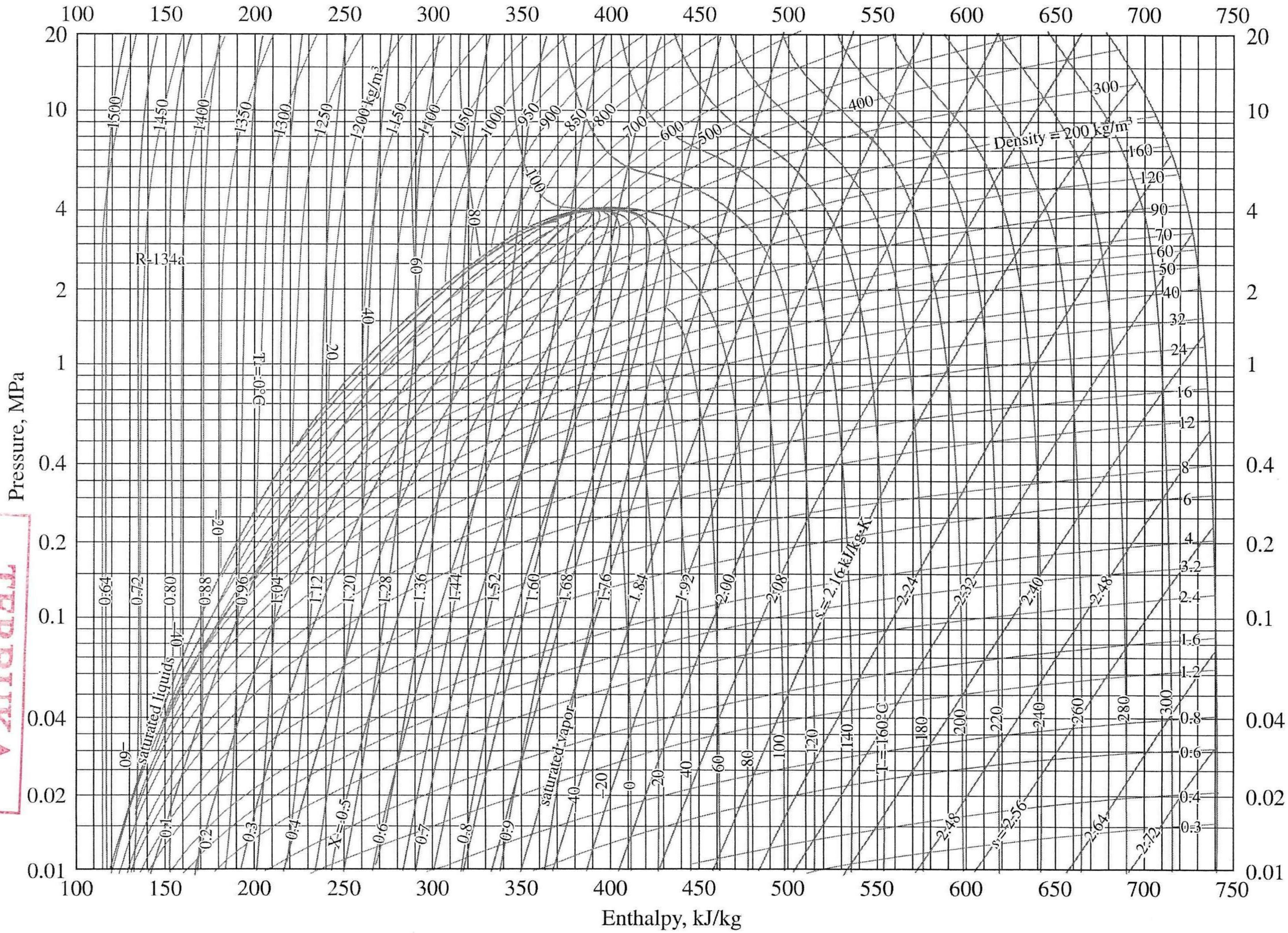
R-134a
Pressure, MPa
Enthalpy, kJ/kg
Density = 200 kg/m³
s = 2.16 kJ/kg·K
T = 0°C
T = 160°C
X = 0.5
saturated liquids
saturated vapor

ASHRAE Psychrometric Chart No. 1

Normal Temperature

Barometric Pressure: 101.325 kPa

Sea Level