Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	THERMODYNAMICS
COURSE CODE	:	BDJ 20703
PROGRAMME CODE	:	BDJ
EXAMINATION DATE	:	JULY / AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS 2. THIS FINAL EXAMINATION CONDUCTED VIA **CLOSED BOOK** 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY ETERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) Define the following thermodynamic terms;

(i) System
(ii) State
(iii) Process

(3 marks)

(b) Explain the relationship among those terms.

(2 marks)

(c) Consider the system shown in **Figure Q1(c)**. If a change of 0.7 kPa in the pressure of air causes the brine-mercury interface in the right column to drop by 5 mm in the brine level in the right column while the pressure in the brine pipe remains constant, determine the ratio of A_2/A_1.

(8 marks)

(d) Consider a person standing in a breezy room at 20°C. Determine the total rate of heat transfer from this person if the exposed surface area and the average outer surface temperature of the person are 1.6 m^2 and 29°C, respectively, and the convection heat transfer coefficient is 6 W/m2 · °

(7 marks)

Q2 (a) Sketch the constant pressure lines on T-v diagram for water substance. Show in the diagram clearly

(i) Critical point
(ii) Liquid-vapor water phase
(iii) Saturated liquid line
(iv) Saturated vapor line

(2 marks)

(b) A househusband is cooking beef stew for his family in a pan that is (*i*) uncovered, (*ii*) covered with a light lid, and (*iii*) covered with a heavy lid. In which of the following scenarios will the cooking time be the shortest? Explain in detail the scenarios.

(2 marks)

(c) A piston cylinder device initially contains 50 litre of liquid water at 25°C and 300 kPa. Heat is added to water at constant pressure until the entire water is vaporized. Calculate

(i) the mass of water

(3 marks)

(ii) the temperature at which the water vaporizes

(2 marks)

(iii) the total enthalpy change

(3 marks)

(v) illustrate the process on a T-V diagram with respect to saturation lines

(2 marks)

(d) The pressure in an automobile tire depends on the temperature of the air in the tire as shown in **Figure Q2(d)**. When the air temperature is 25°C, the pressure gage reads 210 kPa. If the volume of the tire is 0.025 m^3, determine the pressure rise in the tire when the air temperature in the tire rises to 50°C. Also, determine the amount of air that must be bled off to restore pressure to its original value at this temperature. Assume the atmospheric pressure is 100 kPa.

(6 marks)

Q3 (a) A rigid tank is divided into two equal parts by a partition. Initially, one side of the tank contains 5 kg of water at 200 kPa and5°C, and the other side is evacuated. The partition is then removed, and the water expands into the entire tank. The water is allowed to exchange heat with its surroundings until the temperature in the tank returns to the initial value of 25°C. Determine

(i) the volume of the tank

(2 marks)

(ii) the final pressure

(2 marks)

(iii) the heat transfer for this process.

(6 marks)

(b) Refrigerant-134a enters a diffuser steadily as saturated vapor at 800 kPa with a velocity of 120 m/s, and it leaves at 900 kPa and 40°C. The refrigerant is gaining heat at a rate of 2 kJ/s as it passes through the diffuser. If the exit area is 80 percent greater than the inlet area, determine

(i) the exit velocity

(2 marks)

(ii) the mass flow rate of the refrigerant.

(3 marks)

(c) A hot water stream at 80°C enters a mixing chamber with a mass flow rate of 0.5 kg/s where it is mixed with a stream of cold water at 20°C as shown in **Figure Q3(c)**. If it is desired that the mixture leave the chamber at 42°C, determine the mass flow rate of the cold-water stream. Assume all the streams are at a pressure of 250 kPa.

(5 marks)

Q4 (a) Proof that the violation of the Kelvin–Planck statement leads to the violation of the Clausius statement.

(4 marks)

(b) Refrigerant-134a enters the condenser of a residential heat pump at 800 kPa and 35°C at a rate of 0.018 kg/s and leaves at 800 kPa as a saturated liquid as depicted in **Figure Q4(b)**. If the compressor consumes 1.2 kW of power, determine

(i) the COP of the heat pump

(4 marks)

(ii) the rate of heat absorption from the outside air

(2 marks)

(c) Briefly explain on the four processes that make up the Carnot cycle

(3 marks)

(d) A Carnot heat engine receives heat from a reservoir at 900°C at a rate of 800 kJ/min and rejects the waste heat to the ambient air at 27°C. The entire work output of the heat engine is used to drive a refrigerator that removes heat from the refrigerated space at -5°C and transfers it to the same ambient air at 27°C. Determine

(i) the maximum rate of heat removal from the refrigerated space

(3 marks)

(ii) the total rate of heat rejection to the ambient air.

(4 marks)

Q5 (a) Describe the ideal process for an adiabatic turbine, adiabatic compressor and adiabatic nozzle, and define the isentropic efficiency for each device.

(4 marks)

(b) A rigid tank contains 5 kg of refrigerant-134a initially at 20°C and 140 kPa. The refrigerant is now cooled while being stirred until its pressure drops to 100 kPa. Determine the entropy change of the refrigerant during this process.

(6 marks)

(c) Steam enters an adiabatic turbine steadily at 3 MPa and 400°C and leaves at 50 kPa and 100°C. If the power output of the turbine is 2 MW, determine

(i) the isentropic efficiency of the turbine

(5 marks)

(ii) the mass flow rate of the steam flowing through the turbine.

(5 marks)

END OF QUESTIONS

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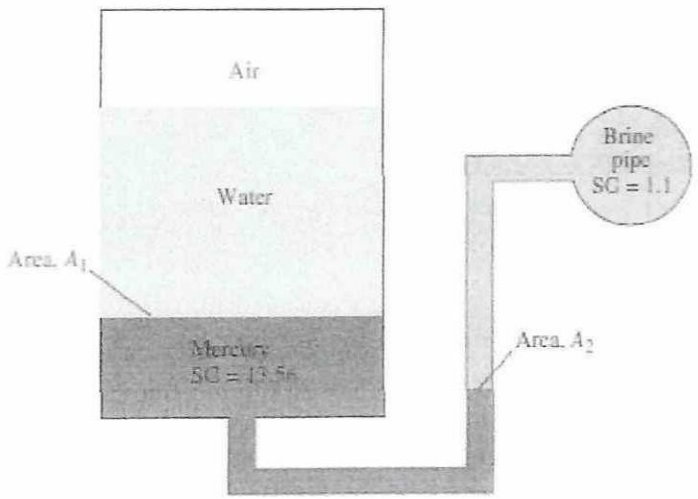

Figure Q1(c)

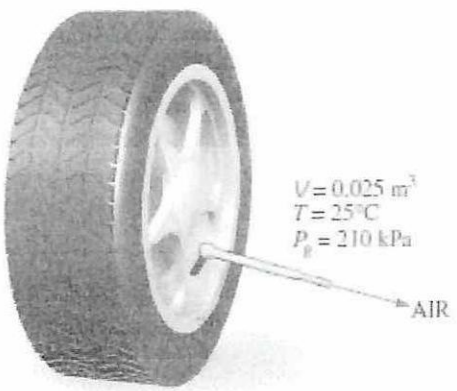

Figure Q2(b)

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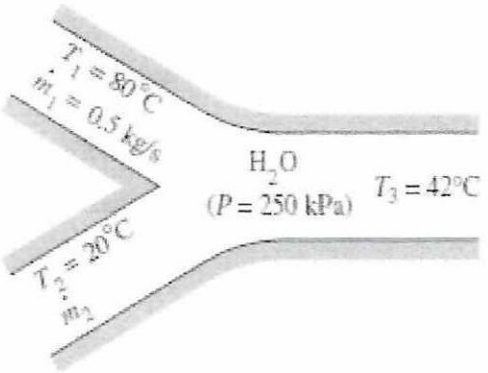

Figure Q3(c)

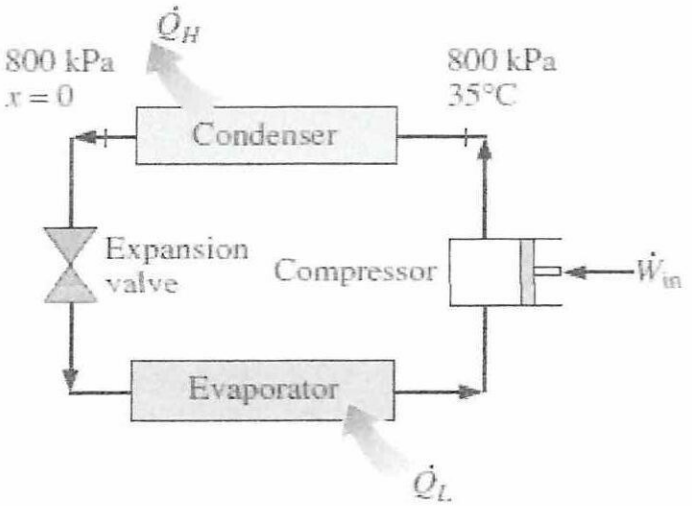

Figure Q4(c)