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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	THERMODYNAMICS
COURSE CODE	:	DAM23403
PROGRAMME CODE	:	DAM
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER **FIVE (5)** QUESTIONS ONLY 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA **CLOSED BOOK**

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

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Q1 (a) State the following definitions of:

(i) second Law of Thermodynamics

(1 mark)

(ii) isothermal process

(1 mark)

(iii) isobaric process

(1 mark)

(iv) adiabatic process

(1 mark)

(b) Equip with example, explain:

(i) closed system

(2 marks)

(ii) open system

(2 marks)

(iii) isolated system

(2 marks)

(c) Identify difference between an intensive and an extensive property. Give two (2) examples for each type of property.

(6 marks)

(d) The absolute pressure in water at a depth of 4 m is 218500 Pa. Determine:

(i) the local atmospheric pressure given density of water is 1000 kgm^{-3} and gravity acceleration is $9.81ms^{-2}$; and

(2 marks)

(ii) the absolute pressure at a depth of 65 cm in a liquid whose specific gravity is 0.75 at the same location.

(2 marks)

Q2 (a) Plot and label clearly the following on a *T-v* diagram of pure substance.

(i) Saturated liquid line (1 mark)

(ii) Saturated vapor line (1 mark)

(iii) Critical point (1 mark)

(iv) Compressed liquid region (1 mark)

(v) Saturate liquid-vapor mixture region (1 mark)

(vi) Superheated vapor region (1 mark)

(b) A 4 kg of refrigerant-134a initially at 140 kPa and 24°C is cooled at constant volume as it is stirred until the temperature drop to -26°C. Using Thermodynamics Table, determine:

(i) the volume at initial and final state in m^3 and (3 marks)

(ii) the dryness fraction at final state, and (2 marks)

(iii) the change in internal energy in kJ/kg and (6 marks)

(iv) Show the process on a *T-v* diagram with appropriate labels. (3 marks)

Q3 (a) Explain whether ice (H_2O) can be considered as pure substance or not.
(3 marks)

(b) What is quality (*X*)? Does it have any meaning in the compressed liquid region?
(2 marks)

(c) A piston–cylinder device contains 0.6 kg of steam at 200°C and 0.5 MPa. Steam is cooled at constant pressure until one-half of the mass condenses.

(i) Determine the phase description of the steam inside the piston cylinder device initially (before cooling process)
(1 mark)

(ii) Find the final temperature.
(2 marks)

(iii) Determine the volume change.
(6 marks)

(d) A rigid vessel contains 8 kg of refrigerant-134a (R-134a) at 500 kPa and 120°C.

(i) Determine the phase description of R134-a inside the vessel.
(1 marks)

(ii) Calculate the volume of the vessel, (V) in m^3.
(3 marks)

(iii) Calculate the total internal energy, (U) in kJ
(2 marks)

Q4 (a) Sketch a schematic diagram and explain the main function of following steady state device.

(i) Compressor

(2 marks)

(ii) Heat exchanger

(2 marks)

(iii) Throttling valve

(2 marks)

(b) **Figure Q4.1** showed a feedwater heater at a steam power plant that act as a mixing chamber. The feedwater heater operates at a pressure of 1000 kPa. Feedwater at 50°C and 1000 kPa is to be heated with superheated steam at 200°C and 1000 kPa. In an ideal feedwater heater, the mixture leaves the heater as saturated liquid at the feedwater pressure. Determine the ratio of the mass flow rates of the feedwater.

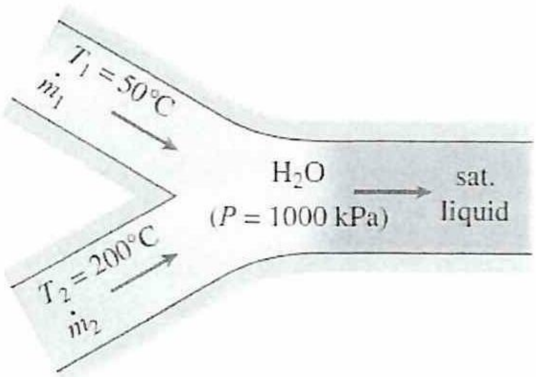

Figure Q4.1: Feedwater heater in Steam Power Plant

(5 marks)

(b) An adiabatic gas turbine expands air at 1300 kPa and 500°C to 100 kPa and 127°C. Air enters the turbine through a 0.2 m^2 opening with an average velocity of 40 m/s, and exhausts through a 1 m^2 opening. Assume air as ideal gas with $C_p = 1.048$ kJ/kg.K and $R = 0.287$ kJ/kg.K, determine:

(i) the mass flow rate of air through the turbine and

(4 marks)

(ii) the power produced by the turbine.

(5 marks)

Q5 (a) List two (2) example of thermal energy reservoir.

(2 marks)

(b) Prof H claims to have invented a newly concept of a heat engine that develops a thermal efficiency of 85 percent when operating between two heat reservoirs at 1000 K and 300 K. Proof and evaluate whether his claim is true or false.

(5 marks)

(c) A domestic food freezer maintains a temperature of -15°C. The ambient air is at 30°C. If the heat leaks into the freezer at a continuous rate of 1.75 KJ/s, what is the least power necessary to pump the heat out continuously.

(5 marks)

(d) A heat pump with 7.07 kW of electric power was provided the heat energy to a house at a rate of 64,400 kJ / hour. Calculate the:

(i) heat pump's coefficient of performance, COP_{HP},

(2 marks)

(ii) rate of heat absorption from the outside air, Q_L.

(3 marks)

(e) Heat pump used to heat a house runs about one third of the time. The house is losing heat at an average rate of 22,000 kJ/h. If the COP of the heat pump is 2.8, determine the power the heat pump draws when running.

(3 marks)

Q6 (a) State **three (3)** conclusions that can be made based on the Clausius inequality, $\oint \frac{\delta Q}{T} \leq 0$.

(3 marks)

(b) A steam power plant operates between 1200 K and 500 K reservoirs. The power plant receives 3500 kJ from the heat reservoir then it produce 2000 kJ of work. Determine the operating status plant cycle whether it is reversible, irreversible or impossible to use.

(7 marks)

(c) An air compressor is used to supply compressed air at a rate of $0.3 kgs^{-1}$ at a pressure of 4 bar and a temperature of 60°C. Atmospheric air conditions are 1 bar and temperature is 27°C. If the required compressor power is 20 kW, determine:

(i) entropy change,

(4 markah)

(ii) heat transfer rate, and

(3 markah)

(iii) the rate of entropy generation.

(3 markah)

For air: take C_p = 1.005 kJ/kg.K and R = 0.287 kJ/kg.K

-END OF QUESTIONS –