Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	THERMODYNAMICS
COURSE CODE	:	DAM 23403
PROGRAMME CODE	:	DAM
EXAMINATION DATE	:	JULY / AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER **FIVE (5)** QUESTIONS ONLY
		2. THIS FINAL EXAMINATION IS CONDUCTED VIA **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 **NINE (9)** PAGES

Q1 (a) Explain the following term of thermodynamics:

(i) Control mass

(2 marks)

(ii) Control volume

(2 marks)

(iii) Second law of thermodynamics

(2 marks)

(iv) Adiabatic process

(2 marks)

(v) Isobaric process

(2 marks)

(b) **Figure Q1(b)** showed a simplified diagram of a hydroelectric dam. Maximum discharge of water to the turbine is at a rate of 140 m^3/s. The dam was designed to hold and release water from 155m elevation difference (z) to generate power. Given gravitational acceleration g = 9.81 ms^{-2} and density of water, ρ = 1000 kgm^{-3}:

(i) Calculate the potential energy (PE) of the river water per unit mass (kJ / kg).

(5 marks)

(ii) Determine the power generated ($\dot{W}$) by the hydroelectric dam in MW.

(5 marks)

Q2 (a) Explain the difference between saturated water, saturated mixture water and superheated vapor.

(6 marks)

(b) Find the missing properties and the phase descriptions in the following **Table 1** for water. Each answer must be supported by related calculation.

Table 1: Properties of H_20

No.	T, °C	P, kPa	u, kJ/kg	x	Phase Description
a)	**A**	850	**B**	0.0	**C**
b)	**D**	200	**E**	0.6	**F**
c)	125	**G**	1600	**H**	**I**

(9 marks)

(c) A rigid tank as shown in **Figure 2(c)** initially contains 2.5 kg saturated liquid water at 80 °C. At this state, 10% of the volume is occupied by water and the rest by air. Now heat (q) is supplied to the tank until the tank completely vaporize and contains saturated vapor only. Determine:

(i) volume of the tank,

(1 mark)

(ii) the final temperature and pressure,

(2 marks)

(iii) the internal energy change of the water.

(2 marks)

Q3 (a) Mr. Rayyan wants to design a piston-cylinder device that works with argon gas as working fluid. He intends to insulate the devices so that there is no interaction with the surrounding. The device will compress that argon gas isothermally. Is the device that Mr Rayyan wants to design will work? Explain your answer.

(3 marks)

(b) A $3m^3$ rigid tank contains hydrogen at 250 kPa and 550 K. The gas is now cooled until its temperature drops to 350 K. Assume hydrogen as ideal gas. The gas constant for hydrogen is 4.124 kJ/kg.K and Cv is 10.377 kJ/kg.K. Determine:

(i) the final pressure in the tank in kPa.

(2 marks)

(ii) the amount of heat transfer (u) in kJ.

(4 marks)

(c) A piston–cylinder device contains 4 kg of argon at 250 kPa and 358 °C. During a quasi-equilibrium, isothermal expansion process, 15 kJ of boundary work is done by the system, and 3 kJ of paddle-wheel work is done on the system. Determine the heat transfer in kJ for this process.

(4 marks)

(d) A 4 m x 5 m x 6 m room is to be heated by a baseboard resistance heater. The resistance heater was designed to be able to raise the air temperature in the room from 5 °C to 25 °C within 11 min. Assuming no heat losses from the room and an atmospheric pressure of 100 kPa, determine the required power of the resistance heater. Assume constant specific heats at room temperature.

(7 marks)

Q4 (a) List **three (3)** types of total energy for a non-flowing fluid.

(3 marks)

(b) The function of compressor in air conditioning unit is to compress and circulate refrigerant gas throughout the system. Refrigerant-134a (R-134a) enters an adiabatic compressor, as saturated vapor at 24 °C and leaves at 0.8 MPa and 60 °C. The mass flow rate ($\dot{m}$) of the refrigerant is 1.2 kg/s. Determine:

(i) the power input ($\dot{W}$) to the compressor in kJ/s and

(5 marks)

(ii) the volume flow rate ($\dot{v}$) of the refrigerant at the compressor inlet in m^3/s.

(2 marks)

(c) Mixing chamber are devices that mix two streams of fluid with different temperature into one single stream with equilibrium temperature. Liquid water at 300 kPa and 20 °C is heated in a chamber by mixing it with superheated steam at 300 kPa and 300 °C. Cold water enters the chamber at a rate of 1.8 kg/s. If the mixture leaves the mixing chamber at 60 °C, determine:

(i) the enthalpy for cold water, superheated steam and mixture in kJ/kg and

(5 marks)

(ii) the mass flow rate ($\dot{m}$) of the superheated steam required in kg/s.

(5 marks)

Q5 (a) Ir. Siew is an engineer at a design company. He proposes a brand new design of a refrigerator that combine chiller and freezer under one compartment instead of separating it like the conventional refrigerator. The combine chiller and freezer will set at -20°C. Explain about this design.

(2 marks)

(b) 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:

(i) Sketch schematic diagram of a refrigerator as mentioned before.

(2 marks)

(ii) Determine the least power necessary to pump the heat out continuously.

(4 marks)

(c) 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) Sketch schematic diagram of heat pump above

(2 marks)

(ii) Heat pump's coefficient of performance, COP_{HP},

(2 marks)

(iii) Rate of heat absorption from the outside air, Q_L.

(2 marks)

(d) A heat engine receives heat from a heat source at 1200°C and rejects heat to a heat sink at 50°C. The heat engine does maximum work equal to 500 kJ.

(i) Sketch schematic diagram of heat engine above.

(2 marks)

(ii) Determine the heat supplied to the heat engine by the heat source and the heat rejected to the heat sink.

(4 marks)

Q6 (a) When a system is adiabatic, what can be said about the entropy change of the substance in the system?

(1 marks)

(b) A steam power plant operates between 900 K and 350 K reservoirs. The power plant receives 2800 kJ from the heat reservoir then it produces 1550 kJ of work. Determine the operating status plant cycle whether reversible, irreversible or impossible to use:

(i) Carnot principle

(2 marks)

(ii) Clausius Inequalities

(2 marks)

(c) Steam enters an adiabatic turbine steadily as illustrated at **Figure 6(c)** at 7MPa, 500°C, and 45 m/s, and leaves at 100 kPa and 75 m/s. If the power output of the turbine is 5 MW and the isentropic efficiency is 77 percent, determine:

(i) the mass flow rate of steam through the turbine

(2 marks)

(iii) the temperature at the turbine exit

(3 marks)

(iii) the rate of entropy generation during this process.

(2 marks)

(d) Refrigerant-134a is throttled in a throttling valve as shown in **Figure 6(d)** from 900 kPa and 35°C to 200 kPa. Heat is lost from the refrigerant in the amount of 0.8 kJ/kg to the surroundings at 25°C. Determine:

(i) the exit temperature of the refrigerant

(4 marks)

(ii) the entropy generation during this process.

(4 marks)

- END OF QUESTION -

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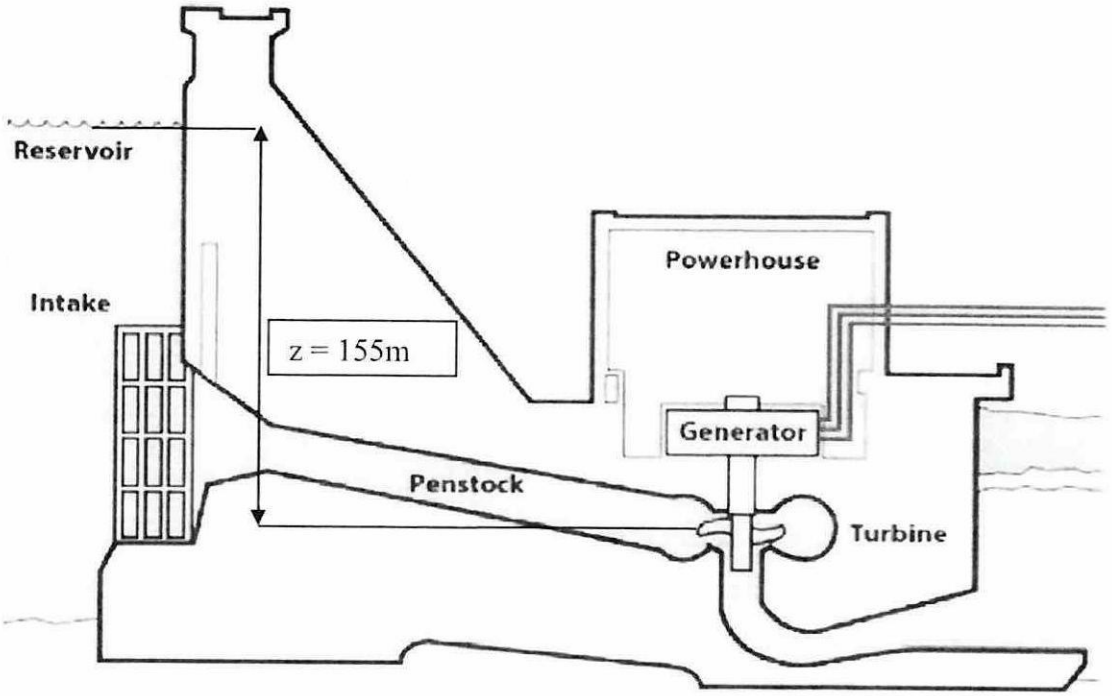

Figure Q1(b): Simplified Diagram of Hydroelectric Dam

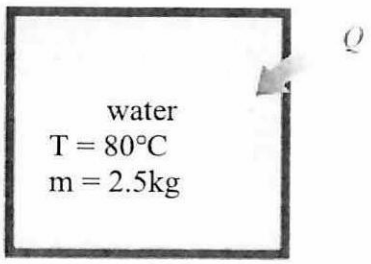

Figure Q2(c): Rigid Tank

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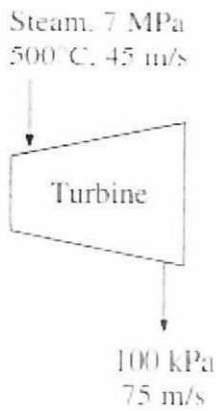

Figure 6(c)

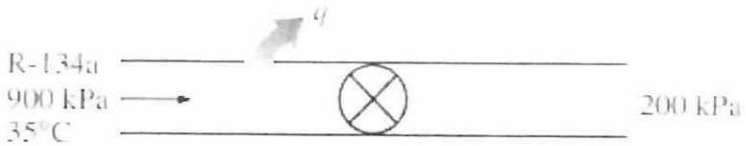

Figure 6(d): Throttling Valve