UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSE NAME	:	THERMODYNAMICS I
COURSE CODE	:	BDA20703
PROGRAMME	:	BDD
EXAMINATION DATE	:	JULY 2022
DURATION	:	3 HOURS
INSTRUCTION	:	1. PART A: ANSWER **FOUR (4)** QUESTIONS ONLY, AND PART B: ANSWER **ALL** QUESTIONS. 2. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT 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 **SIX (6)** PAGES

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PART A

Q1 (a) What is the difference between an open system and a closed system from a thermodynamics point of view? Illustrate by sketching both systems, complete with their boundaries, mass, and energy that cross the boundaries.

(6 marks)

(b) The absolute pressure of the manometer shown in **Figure Q1(b)** is 270 kPa. If the specific gravity of oil is 0.82 and the specific gravity of kerosene is 0.75. Determine the local atmospheric pressure in bar.

(14 marks)

Q2 (a) Two-phases fluid inside a tank, as shown in **Figure Q2(a),** are well mixed between saturated liquid and saturated vapor, forming a homogeneous mixture with average properties. Suppose the volume occupied by saturated liquid is $\mathbf{V}_f$, the volume occupied by the saturated vapor is $\mathbf{V}_g$, and the total volume is **V**. Derive the equation of average specific volume, v_{avg} as:

$$v_{avg} = v_f + x.(v_g - v_f)$$

where, x is a ratio of the vapor mass to the total mass of the fluid.

(5 marks)

(b) Using the condition from question **Q2(a)**, if the fluid used is water, the total tank volume is 0.04 m^3, the volume occupied by saturated water is 0.02 m^3, and the temperature of the mixture is 270°C. Determine:

(i) the total mass of the mixture;

(8 marks)

(ii) quality of the mixture; and

(2 marks)

(iii) the specific volume of the mixture.

(2 marks)

Sketch the state of the mixture on *T-v* or *P-v* diagram based on the above condition.

(3 marks)

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Q3 (a) Derive the equation for work produced by the polytropic expansion process of an ideal gas inside a piston-cylinder device when the process is undergoing an isothermal condition. Show $\frac{V_2}{V_1} = \frac{P_1}{P_2}$ in your derivation.

(5 marks)

(b) Air is contained inside a piston-cylinder device at 500 kPa and 627°C, and it occupies a volume of 0.6 m^3. The air undergoes a constant temperature process until the pressure is reduced to 250 kPa. The piston is then fixed in place so that it is not allowed to move, and at the same time, heat transfer occurs between the system and its surrounding, causing the air temperature to be reduced to the ambient temperature of 27°C. Determine:

(i) the work produced; and

(10 marks)

(ii) the amount of heat transfer of the system.

(5 marks)

Q4 (a) A hairdryer shown in **Figure Q4(a)**, comes with a constant duct diameter and has a few layers of electric resistors placed in it. A small fan pulls the air in and forces it through the resistors where it is heated. If the density of air is 1.20 kg/m^3 at the inlet (point 1) and 1.05 kg/m^3 at the exit (point 2), determine the percent increase in the velocity of air as it flows through the dryer.

(5 marks)

(b) Air flows steadily through an air compressor at a rate of 0.4 kg/s, as shown in **Figure Q4(b)**. The air enters the compressor at 6 m/s with a pressure of 1 bar and a specific volume of 0.85 m^3/kg. It leaves at 4.5 m/s with a pressure of 6.9 bar and a specific volume of 0.16 m^3/kg. The internal energy of the air leaving the compressor is 88 kJ/kg greater than that of the air entering it. Cooling water absorbs heat from the air at the rate of 59 kW in a jacket surrounding the compressor cylinder. Determine:

(i) the power required to drive the compressor;

(10 marks)

(ii) the inlet cross-section area of the pipe; and

(3 marks)

(iii) the outlet cross-section area of the pipe.

(2 marks)

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Q5 (a) An inventor claims to have developed a heat engine that receives 800 kJ of heat from a source at 327°C and produces 400 kJ of net work while rejecting the waste heat to a sink at 47°C. Is this a reasonable claim? Why?

(5 marks)

(b) A heat pump shown in **Figure Q5(b)** comprises four (4) basic components. It uses R-134a as a refrigerant and utilizes 700 W to drive its compressor. During heat pump operation, its refrigerant enters the condenser at 770 kPa and 38°C at a rate of 0.02 kg/s and leaves at constant pressure as a saturated liquid. Determine:

(i) the rate of heat rejected by the condenser;

(11 marks)

(ii) the rate of heat absorption from the surrounding; and

(2 marks)

(iii) the COP of the heat pump.

(2 marks)

PART B

Q6 (a) What happens to the entropy if an expansion process undergoes an internally reversible and adiabatic manner? Sketch the process and plot the initial and final state on a *T-s* diagram.

(3 marks)

(b) Air enters an adiabatic steady flow nozzle at 470 kPa and 527°C with low velocity and exits at 260 m/s. If the isentropic efficiency of the nozzle is 92%, determine the exits temperature and pressure of the air.

(17 marks)

– END OF QUESTION –

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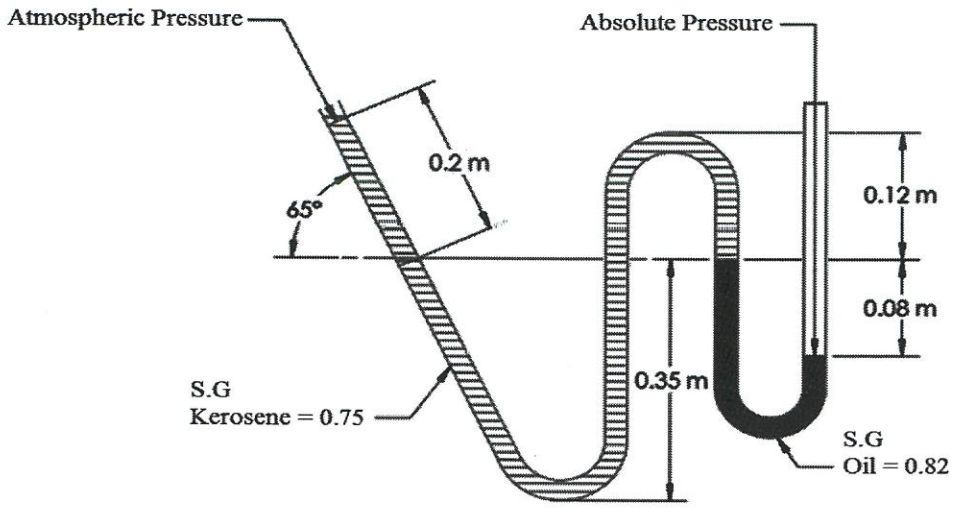

Figure Q1(b)

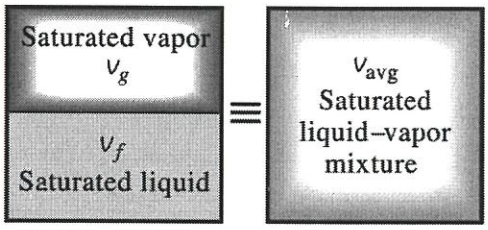

Figure Q2(a)

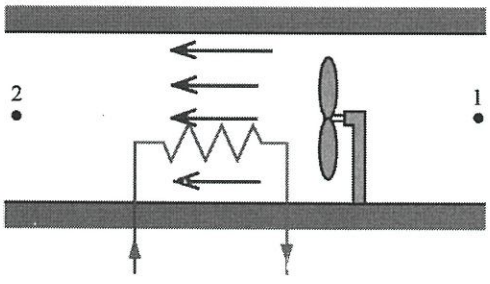

Figure Q4(a)

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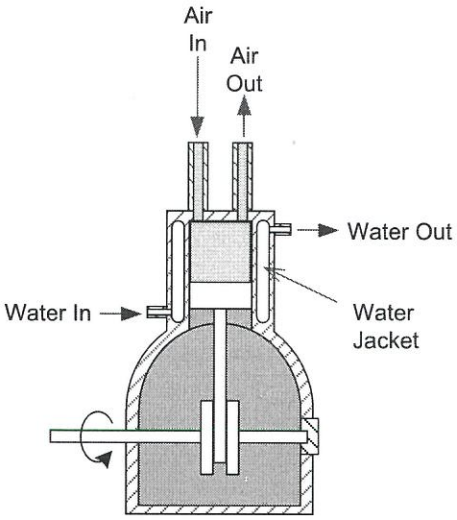

Figure Q4(b)

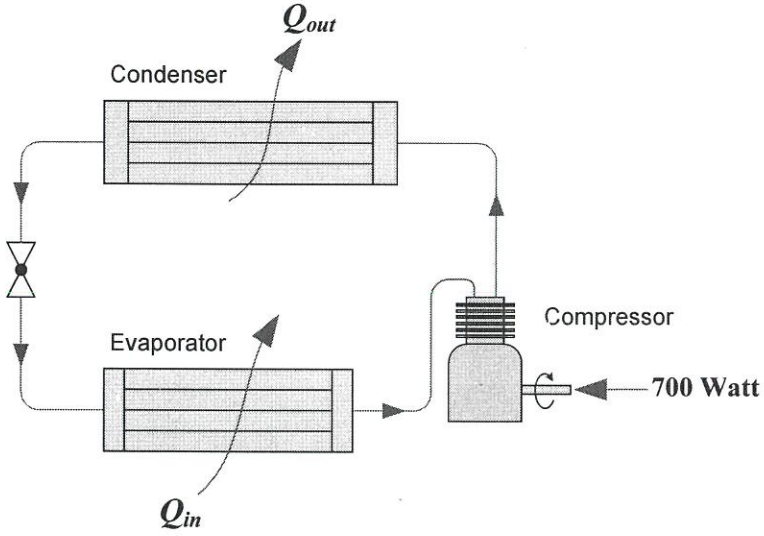

Figure Q5(b)

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