UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2019/2020

COURSE NAME	:	THERMODYNAMICS I
COURSE CODE	:	BDA 20703
PROGRAMME	:	BDD
EXAMINATION DATE	:	JULY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	**PART A**: ANSWER **TWO (2)** QUESTIONS **ONLY** FROM **THREE (3)** QUESTIONS. **PART B**: ANSWER **ALL** QUESTIONS. **ONLINE EXAMINATION**

THIS QUESTION PAPER CONSISTS OF SEVEN (7) PAGES

PART A: ANSWER TWO (2) QUESTIONS ONLY FROM THREE (3) QUESTIONS.

Q1 (a) Explain the characteristics of an open and a closed thermodynamic system in terms of the system mass and energy flow and include an example for each system.

(8 marks)

(b) The pressure drop of air across a pipe section is measured by a differential manometer which is connected through pressure tappings on the pipe wall as shown in **Figure Q1 (b)**. Oil with a specific gravity of SG_{oil} = 0.96 is used as the manometer fluid. The differential height h is measured to be 45 mm while the distance a is 50 mm. Taking the density of air to be ρ_{air} = 1.225 kg/m3 and ρ_{water} = 998 kg/m^3 respectively, determine:

(i) The density of the manometer fluid;

(ii) The pressure drop ΔP along the pipe section; and

(iii) The differential height, h if the manometer fluid is replaced with mercury with specific gravity SG_{Hg} = 13.6.

(17 marks)

Q2 (a) A piston–cylinder device contains 0.8 kg of steam at 300°C and 1 MPa. Steam is cooled at constant pressure until one-half of the mass condenses.

(i) Show the process on a *T*-*v* diagram.

(ii) Find the final temperature.

(iii) Determine the volume change.

(12 marks)

(b) A 1-m^3 tank containing air at 25°C and 500 kPa is connected through a valve to another tank containing 5 kg of air at 35°C and 200 kPa. Now the valve is opened, and the entire system is allowed to reach thermal equilibrium with the surroundings, which are at 20°C. Determine the volume of the second tank and the final equilibrium pressure of air.

(13 marks)

Q3 (a) A closed system undergoes a process in which there is no internal energy change. During this process, the system produces 14×10^5 N m. of work. Calculate the heat transfer for this process, in Mega Joule (MJ).

(7 marks)

(b) An adiabatic air compressor is to be powered by a direct-coupled adiabatic steam turbine that is also driving a generator as shown in **Figure Q3 (b)**. Steam enters the turbine at 12.5 MPa and 500°C at a rate of 25 kg/s and exits at 10 kPa and a quality of 0.92. Air enters the compressor at 98 kPa and 295 K at a rate of 10 kg/s and exits at 1 MPa and 620 K. Determine the net power delivered to the generator by the turbine.

(18 marks)

PART B: ANSWER ALL QUESTIONS.

Q4 (a) Water enters an ice machine at 12.8 °C and leaves as ice at - 4 °C. If the COP of the ice machine is 2.4 during this operation, determine the required power input for an ice production rate of 0.0035 kg/s and sketch the schematic for this problem. (178.3 kJ of energy needs to be removed from each kg of water at 12.8 °C to turn it into ice at - 4 °C.)

(7 marks)

(b) A Carnot heat engine receives heat from a reservoir at 930°C at a rate of 12.31 kW and rejects the waste heat to the ambient air at 27°C as shown in **Figure Q4 (b)**. The entire work output of the heat engine is used to drive a refrigerator that removes heat from the refrigerated space at – 7 °C and transfers it to the same ambient air at 27°C. Determine:

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

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

(18 marks)

Q5 (a) (i) Does the temperature in the Clausius inequality relation have to be absolute temperature? Why?;

(3 marks)

(ii) Does the cyclic integral of heat have to be zero (i.e. does a system have to reject as much heat as it receives to complete a cycle)? Explain; and

(2 marks)

(iii) What three different mechanisms can cause the entropy of a control volume to change?

(2 mark)

(b) (i) Air is compressed by a 20-kW compressor from P_1 to P_2 as shown in **Figure Q5 (b)(i)**. The air temperature is maintained constant at 25°C during this process as a result of heat transfer to the surrounding medium at 20°C. Determine the rate of entropy change of the air. State the assumptions made in solving this problem. Noting that h = h(T) for ideal gases, we have $h_1 = h_2$ since $T_1 = T_2 = 25°C$.

(8 marks)

(ii) A completely reversible heat pump produces heat at a rate of 300 kW to warm a house maintained at 24°C as shown in **Figure Q5 (b)(ii)**. The exterior air, which is at 7°C, serves as the source. Calculate the rate of entropy change of the two reservoirs and determine if this heat pump satisfies the second law according to the increase of entropy principle.

(10 marks)

– END OF QUESTION –

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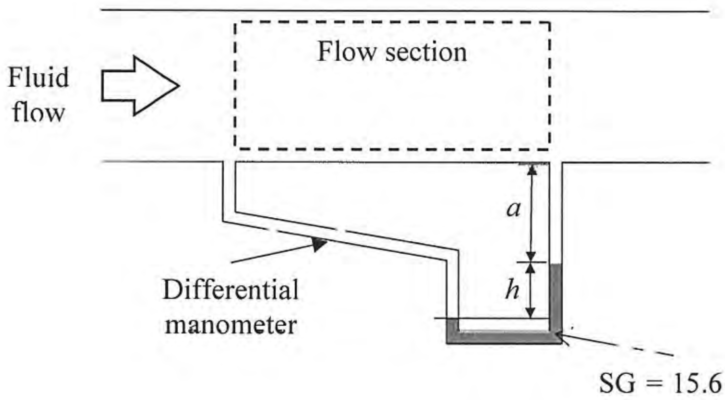

Figure Q1(b)

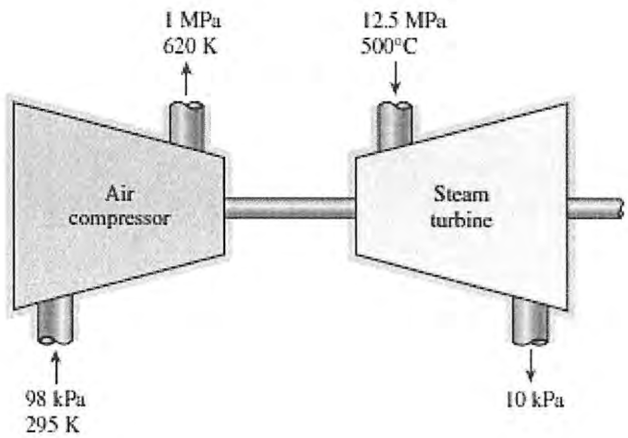

FIGURE Q3 (b)

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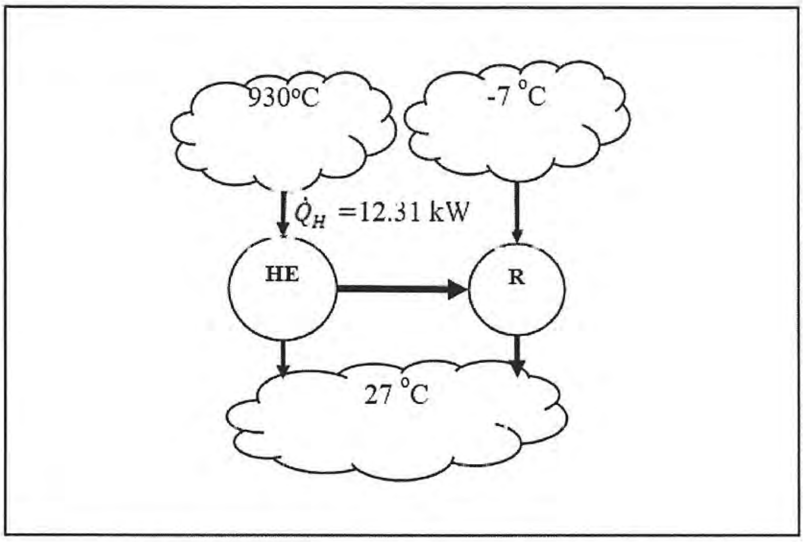

FIGURE Q4 (b): Schematic for Q4 (b)

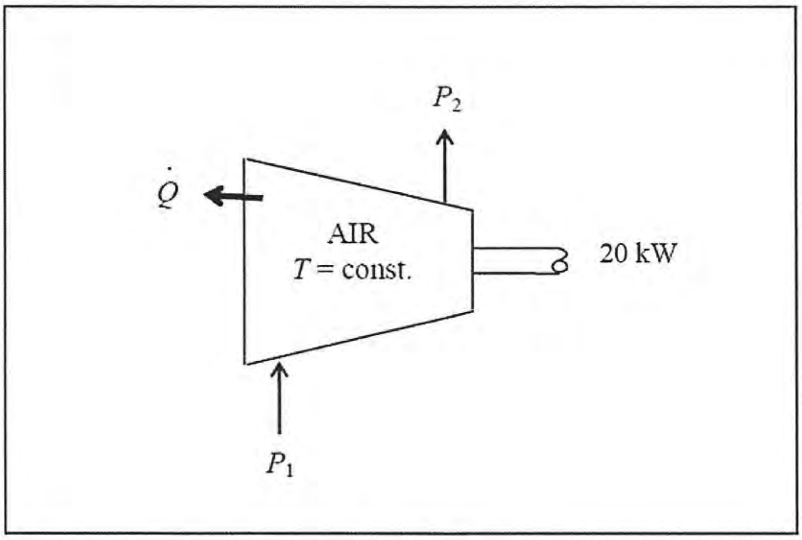

FIGURE Q5 (b)(i)

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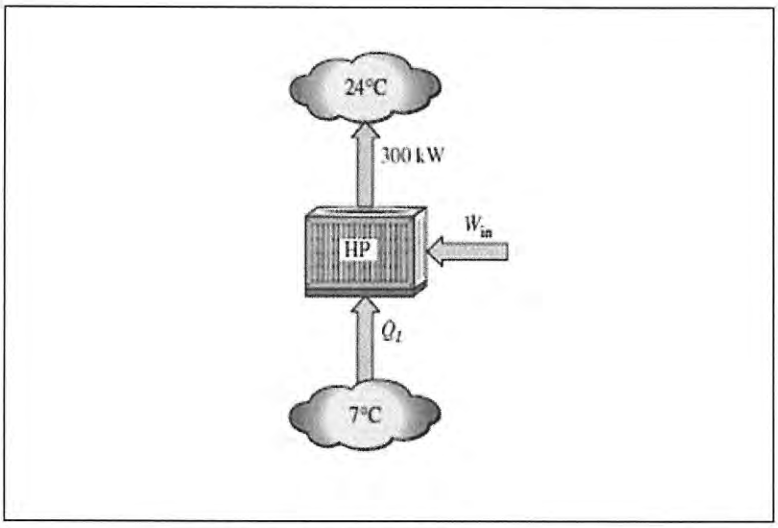

FIGURE Q5 (b)(ii)