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CONFIDENTIAL

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UNIVERSITI KUALA LUMPUR

MALAYSIA FRANCE INSTITUTE

FINAL EXAMINATION

JANUARY 2014 SESSION

SUBJECT CODE	:	**NMB 21303**
SUBJECT TITLE	:	**THERMODYNAMICS 1**
LEVEL	:	**BACHELOR**
TIME/DURATION	:	**3 HOURS**
DATE	:	

INSTRUCTIONS TO CANDIDATES

1. **Please read the instructions given in the question paper CAREFULLY.**
2. **Please write your answers on the answer booklet provided.**
3. **Answer should be written in blue or black ink except for sketching, graphic and illustration.**
4. **This question paper consists of 6 questions. Answer ANY FIVE (5) questions.**
5. **Answer all questions in English.**
6. **Table of properties is provided.**

THERE ARE 5 PRINTED PAGES OF QUESTIONS EXCLUDING THIS PAGE.

INSTRUCTION: Answer FIVE(5) questions only

Please use the answer booklet provided.

Question 1

It is proposed to lift a 1000 kg vehicle using a piston cylinder device that contains R-134a. This system will be driven by a waste heat (60 ^{o}C) that is readily available. The maximum height required for the lifting process is 1.5 meter. It is recommended to allow the R-134a to change its phase from saturated liquid to saturated vapour throughout the lifting process.You may assume the atmospheric pressure is 100 kPa. Answer the questions below:

a) Calculate the minimum diameter of the piston.

(5 marks)

b) Using the minimum diameter of piston in part (a), calculate the minimum mass of R-134a in the cylinder that will satisfy the recommendation.

(10 marks)

c) Evaluate the performance of this piston-cylinder device if water is used as the fluid instead of R-134a.

(5 marks)

Question 2

An engineer proposed a novel heating system for a 120 m^3 room using a tank of hot water as a heat source. The mass of water inside the tank is 1000 kg. The room is initially at 20 ^oC and 100 kPa. It is required to maintain the average temperature of air inside the room at 20 ^oC for a period of 24-hour. Answer the following questions:

a) If the room losses heat at 6000 kJ/hour, calculate the minimum initial temperature of water.

(16 marks)

b) Discuss ONE(1) methods that could be used to reduce the required mass of water

(4 marks)

Question 3

A cross flow heat exchanger (Figure 1) allows heat exchange between water and air. Water enters at 90 ^oC and leaves at 70 ^oC. Due to imperfectness of this heat exchanger, 10 % of mass of air that enters the heat exchanger is loss to surrounding at the average temperature of 37 ^oC. Answer the following questions:

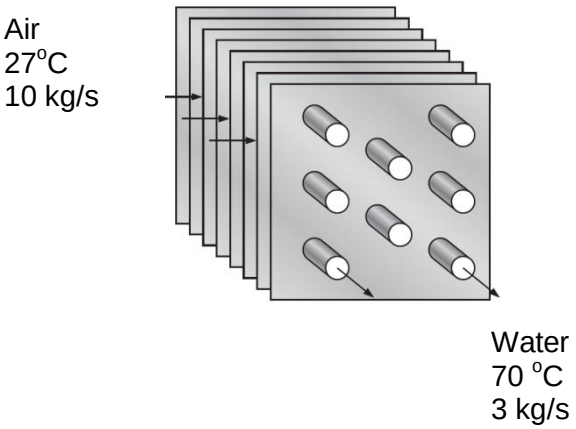

Figure 1

a) Derive the energy balance equation for this system

(6 marks)

b) Calculate the temperature of air at the outlet

(14 marks)

Question 4

A heat pump heats a house in the winter and then reverses to cool it in the summer. The interior temperature should be 23°C in the winter and 25°C in the summer. Heat transfer through the walls and ceilings is estimated to be 2000 kJ per hour per degree temperature difference between the inside and outside. Answer the following questions:

a) Show that the Coefficient of Performance (CoP) of a reversible refrigerator and a reversible heat pump can be written as follow:

Reversible refrigerator $COP_{R,rev} = \frac{1}{\frac{T_H}{T_L} - 1}$

Reversible heat pump $COP_{HP,rev} = \frac{1}{1-\frac{T_L}{T_H}}$

where T_H and T_L are the high and low temperature, respectively

(10 marks)

b) During winter, outside temperature is 0°C. Calculate the minimum power required by the heat pump?

(4 marks)

c) For the same power as in part (b), calculate the maximum outside summer temperature for which the house can be maintained at 25°C?

(6 marks)

Question 5

The feedwater is usually heated in a heat exchanger that is called as feedwater heater. Steam enters the feedwater heater at 2 MPa and 250 ^{o}C and leaves as saturated liquid at the same pressure. Feedwater enters the feedwater heater at 3 MPa and 30 ^{o}C and leaves 22.38^{o}C below the exit temperature of the steam.Answer the following questions:

a) Determine the required mass flow rate of steam if the mass flow rate of feedwater is 1 kg/s

(10 marks)

b) Calculate the total entropy generation for this process. Evaluate your answer.

(10 marks)

Question 6

A mixing chamber is used to heat liquid water by mixing it with saturated steam. Liquid water enters the mixing chamber at 15 ^{o}C at the rate of 4.6 kg/s. The saturated steam enters at the rate of 0.23 kg/s. The mixture leaves at 45 ^{o}C as liquid. Surrounding temperature is at 15 ^{o}C. Answer the following questions:

a) Calculate the temperature of steam when it enters the mixing chamber

(8 marks)

b) Calculate the exergy destruction and the second-law efficiency of this mixing chamber

(12 marks)

END OF QUESTION

Appendix

Second law efficiency $$\eta_{\text{II}} = \frac{\eta_{\text{th}}}{\eta_{\text{th,rev}}} = \frac{W_u}{W_{\text{rev}}}$$

Nonflow exergy: $$\phi = (u - u_0) + P_0(v - v_0) - T_0(s - s_0) + \frac{V^2}{2} + gz$$
$$= (e - e_0) + P_0(v - v_0) - T_0(s - s_0)$$

Flow exergy: $$\psi = (h - h_0) - T_0(s - s_0) + \frac{V^2}{2} + gz$$

General: $$\underbrace{X_{\text{in}} - X_{\text{out}}}_{\substack{\text{Net exergy transfer}\\ \text{by heat, work, and mass}}} - \underbrace{X_{\text{destroyed}}}_{\substack{\text{Exergy}\\ \text{destruction}}} = \underbrace{\Delta X_{\text{system}}}_{\substack{\text{Change}\\ \text{in exergy}}}$$

General, rate form: $$\underbrace{\dot{X}_{\text{in}} - \dot{X}_{\text{out}}}_{\substack{\text{Rate of net exergy transfer}\\ \text{by heat, work, and mass}}} - \underbrace{\dot{X}_{\text{destroyed}}}_{\substack{\text{Rate of exergy}\\ \text{destruction}}} = \underbrace{dX_{\text{system}}/dt}_{\substack{\text{Rate of change}\\ \text{in exergy}}}$$

General, unit-mass basis: $$(x_{\text{in}} - x_{\text{out}}) - x_{\text{destroyed}} = \Delta x_{\text{system}}$$

Exergy transfer by heat: $$X_{\text{heat}} = \left(1 - \frac{T_0}{T}\right)Q$$