



UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
SEPTEMBER 2014 SESSION

SUBJECT CODE : NMB21303
SUBJECT TITLE : THERMODYNAMICS 1
LEVEL : BACHELOR
TIME / DURATION : 9.00 AM – 12.00 PM
(3 HOURS)
DATE : 9 JANUARY 2015

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper **CAREFULLY**.
2. This question paper is printed on both sides of the paper.
3. Please write your answers on the answer booklet provided.
4. Answer should be written in blue or black ink except for sketching, graphic and illustration.
5. This question paper consists of **TWO (2)** sections. Section A and B. Answer all questions in Section A. For Section B, answer three (3) questions only.
6. Answer all questions in English.

THERE ARE 4 PAGES OF QUESTIONS AND 1 PAGE OF APPENDIX, EXCLUDING THIS PAGE.

SECTION A (Total: 40 marks)**INSTRUCTION: Answer ALL questions.****Please use the answer booklet provided.****Question 1**

A tank whose volume is unknown is divided into two parts by partition. One side of the tank contains 0.03 m^3 of refrigerant-134a that is a saturated liquid at 0.9 MPa. Another side of the tank is evacuated. The partition is now removed, and the refrigerant fills the entire tank with the final temperature of 20°C and 280 kPa.

- (a) Sketch T-v diagram to show the initial and final state of refrigerant-134a inside the tank. Explain on how you determine the position of those initial and final states.

(8 marks)

- (b) Calculate the volume of the tank.

(6 marks)

- (c) If the volume of the tank is reduced by half and the pressure is maintained at 280 kPa, evaluate the phase of refrigerant-134a in its final state.

(6 marks)

Question 2

Calorimeter is a device that enables the measurement of heats liberated/absorbed in any processes. Energy content of a fuel could be determined by burning the fuel inside an adiabatic calorimeter. Adiabatic calorimeter usually consists of an insulator, water and a reaction chamber. A calorimeter contains 5 kg of water ($c_p = 4.18 \text{ KJ/kgK}$). It is required to ensure the increase in water temperature should be less than 2 Kelvin.

- (a) Derive an energy balance equation for this system.

(7 marks)

- (b) If the fuel is estimated to have the energy content of 40 kJ/kg, determine the maximum mass of fuel that can be tested in this calorimeter.

(4 marks)

- (c) Discuss **THREE (3)** methods to improve the accuracy of this calorimeter.

(9 marks)

SECTION B (Total: 60 marks)**INSTRUCTION: Answer THREE (3) questions only****Please use the answer booklet provided.****Question 3**

Heat exchangers are devices where two moving fluid streams exchange heat without mixing. Refrigerant R-134a is to be cooled by water in a condenser. The refrigerant enters the condenser with mass flow rate at 6 kg/min at 1 MPa and 70 °C and leaves at 35 °C. The cooling water enters at 300 kPa and 15 °C and leaves at 25 °C. Neglecting any pressure drops determine,

- (a) the mass flow rate of the cooling water required and (10 marks)
- (b) the heat transfer rate from the refrigerant to water pressure of water (10 marks)

Question 4

Ground temperature in Malaysia is constant at 28 °C throughout the year. It is proposed to build a heat pump system to provide hot water at 70 °C utilizing heat from the ground

- (a) Determine the highest possible COP of this heat pump (4 marks)
- (b) The heat pump is required to produce hot water at the rate of 100 kg/hour. Calculate the rate of work input required into the heat pump if the inlet water temperature is at 28 °C. (12 marks)
- (c) Comment on the applicability in using this heat pump compared to the conventional electric water heater (assume that the heat pump is driven by electricity). (4 marks)

Question 5

A rigid tank contains 10 kg of water initially at 200 °C and 1 MPa. The water is now uniformly cooled until its pressure drops 800 kPa. Determine the entropy change of the water.

(20 marks)

Question 6

A piston-cylinder device contains 0.05 kg of steam at 1 MPa and 300 °C. Steam now expands to a final state of 200 kPa and 150 °C, doing work. Heat losses from the system to the surroundings are estimated to be 2 kJ during this process. Assuming the surroundings to be $T_o = 25$ °C and $P_o = 100$ kPa, determine

- (a) the exergy of the steam at the initial and the final states
- (b) the exergy change of the steam
- (c) the exergy destroyed, and
- (d) the second law efficiency for the process

(20 marks)

END OF EXAMINATION PAPER

APPENDIX

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

Nonflow exergy: $\phi = (u - u_0) + P_0(\nu - \nu_0) - T_0(s - s_0) + \frac{V^2}{2} + gz$
 $= (e - e_0) + P_0(\nu - \nu_0) - T_0(s - s_0)$

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

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

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

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