Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2016/2017

COURSE NAME	:	THERMODYNAMICS
COURSE CODE	:	BNJ20703
PROGRAMME	:	BNG / BNH / BNK / BNL / BNM
EXAMINATION DATE	:	DECEMBER 2016 / JANUARY 2017
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 (a) Define the following thermodynamic terms;

(i) System
(ii) State
(iii) Process

(3 marks)

(b) Explain the relationship among those terms.

(2 marks)

(c) **Figure Q1(b)** shows tank A that is within tank B that is within tank C. Manometer D filled with mercury of density 13,600 kg/m^3. Manometer E is filled with Clerici solution. Clerici solution is a solution of equal parts of thallium formate ($Tl(CHO_2)$) and thallium malonate ($Tl(C_3H_3O_4)$) in water. It is a freely flowing, odorless liquid which changes from yellowish to colorless upon decreasing the concentration of the thallium salts. At a density of 4250 kg/m^3 at 20 °C, the saturated Clerici solution is one of the heaviest aqueous solutions known. The pressure gauge A reads 25kPa. The atmospheric pressure and acceleration due to gravity is given 101.325kPa and 9.81 m/s^2 respectively, determine

(i) Vacuum pressure of tank C
(ii) Gauge pressure of tank B
(iii) Absolute pressure of tank A

(10 marks)

(d) Help a buyer evaluate which of these 2 materials would be a cheaper window in terms of material cost, given the area to be 200 cm x 200 cm if the room is maintained at 24°C while the outside temperature is 5°C. The room is heated with a variable electrical resistance heater of 300W. Assume the room does not lose heat to the outside by other means.

Material: Polycarbonate

Thermal conductivity: 0.2 W/(m·K)

Density: 1200 kg/m^3

Price per kg: $12

Material: Glass

Thermal conductivity: 0.8 W/(m·K)

Price per sheet of 12.5mm thickness: $ 50 /m^2

(8 marks)

(e) The buyer decides that the thickness of glass needs to be reduce in half because the material cost is too expensive while maintaining the required temperature using a more powerful heater. Advice the buyer if that is a wise choice or not in terms of energy consumption and cost if the cost of electricity is $0.20 kW/hr.

(2 marks)

Q2 (a) Explain, at constant pressure, the phase changes and changes in specific volume of a pure substance as temperature is increased from compressed liquid to superheated vapour. Draw a corresponding Tv diagram with proper labeling.

(5 marks)

(b) Explain how fish survive in lakes during winter when the water freezes over.

(2 marks)

(c) 7 kg of water vapor at 30 bar and 573 K is contained in the cylinder and piston system. The water is cooled at constant volume until the temperature reaches 473 K, and then compress the water at a constant temperature to 100 bar pressure.

(i) Draw a diagram of the processes occurring in Pv and Tv

(ii) Determine the degree of dryness and pressure at state 2 and the volume of the cylinder at state 3

(8 marks)

Q3 (a) A rigid 10 L vessel initially contains a mixture of liquid water and vapor at 100°C with 12.3 percent quality as shown in **Figure Q3(a)**. The mixture is then heated until its temperature is 50°C. Calculate the heat transfer for this process.

(5 marks)

(b) Derive the equation of a Steady Flow Energy for nozzle to be as shown below,

$$\dot{m}\left(h_1 + \frac{C_1^2}{2}\right) = \dot{m}\left(h_2 + \frac{C_2^2}{2}\right)$$

where m = mass flow rate, h = specific enthalpy and C = velocity.

(3 marks)

(c) Steam flows steadily through an adiabatic turbine as illustrated in **Figure Q3(c)**. The inlet conditions of the steam are 10 MPa, 450°C, and 80 m/s, and the exit conditions are 10 kPa, 92 percent quality, and 50 m/s. The mass flow rate of the steam is 12 kg/s. Determine

(i) the change in kinetic energy,

(3 marks)

(ii) the power output, and

(5 marks)

(iii) the turbine inlet area.

(4 marks)

Q4 (a) Proof that the violation of the Kelvin–Planck statement leads to the violation of the Clausius statement.

(3 marks)

(b) When a man returns to his well-sealed house on a summer day, he finds that the house is at 32°C. He turns on the air conditioner, which cools the entire house to 20°C in 15 min. If the COP of the air-conditioning system is 2.5, determine the power drawn by the air conditioner. Assume the entire mass within the house is equivalent to 800 kg of air for which c_v = 0.72 kJ/kg · °C and c_p =1.0 kJ/kg · °C.

(7 marks)

(c) A Carnot heat engine receives heat from a reservoir at 900°C at a rate of 800 kJ/min and rejects the waste heat to the ambient air at 27°C. The entire work output of the heat engine is used to drive a Carnot refrigerator that removes heat from the refrigerated space at -5°C and transfers it to the same ambient air at 27°C. Determine

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

(5 marks)

(ii) the total rate of heat rejection to the environment.

(5 marks)

Q5 (a) Describe the ideal process for an adiabatic turbine, adiabatic compressor and adiabatic nozzle, and define the isentropic efficiency for each device.

(4 marks)

(b) A rigid tank is divided into two equal parts by a partition as shown in **Figure Q5(b)**. One part of the tank contains1.5 kg of compressed liquid water at 300 kPa and 60°C while the other part is evacuated. The partition is now removed, and the water expands to fill the entire tank. Determine the entropy change of water during this process, if the final pressure in the tank is 15 kPa.

(6 marks)

(c) Refrigerant-134a enters an adiabatic compressor as saturated vapor at120 kPa at a rate of 0.3 m^3/min and exits at 1 MPa pressure as depicted in **Figure Q5(c)**. If the isentropicefficiency of the compressor is 80 percent, determine

(i) the temperature of the refrigerant at the exit of the compressor

(5 marks)

(ii) the power input, in kW. Also, show the process on a *T-s* diagram with respect to saturation lines.

(5 marks)

- END OF QUESTION -

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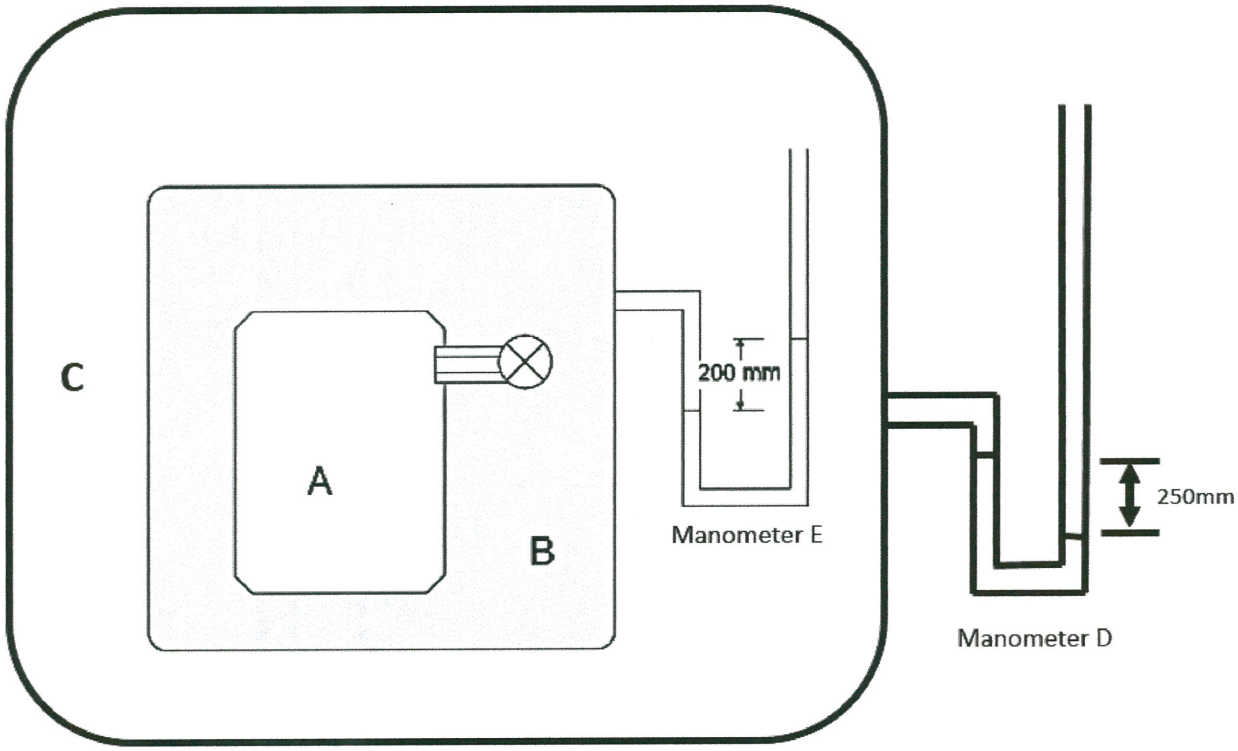

FIGURE Q1(b)

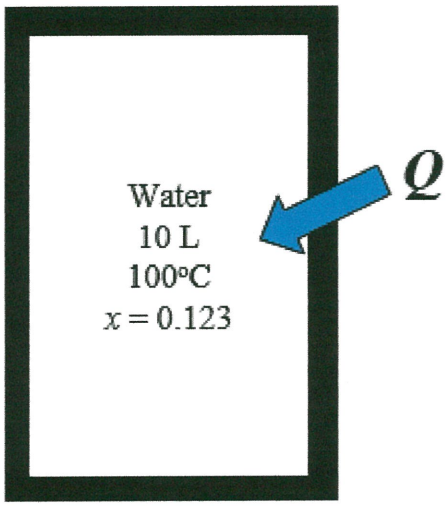

FIGURE Q3(a)

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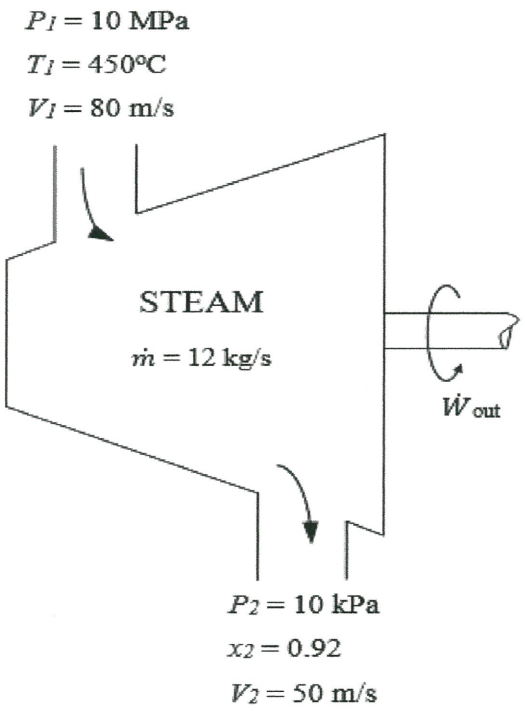

FIGURE Q3(c)

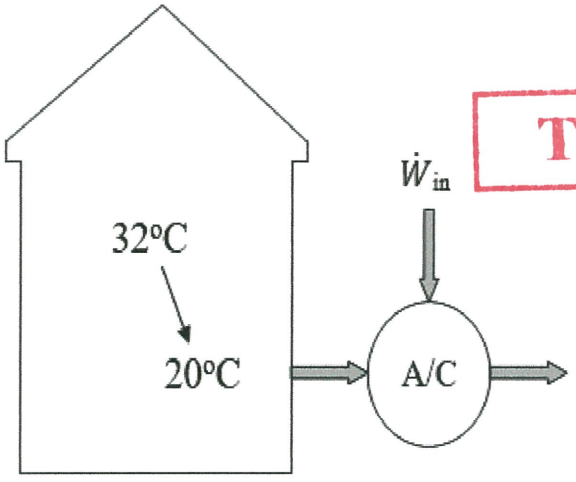

FIGURE Q4(b)

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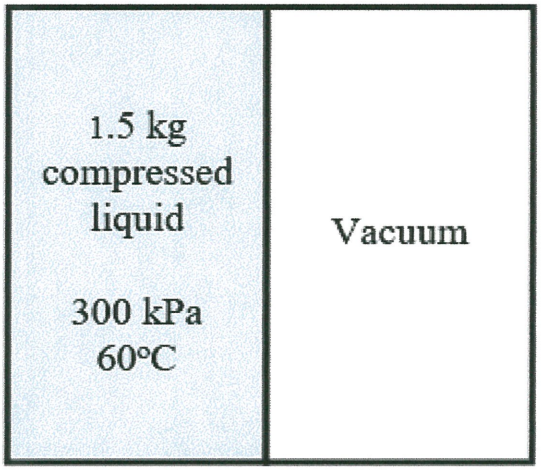

FIGURE Q5(b)

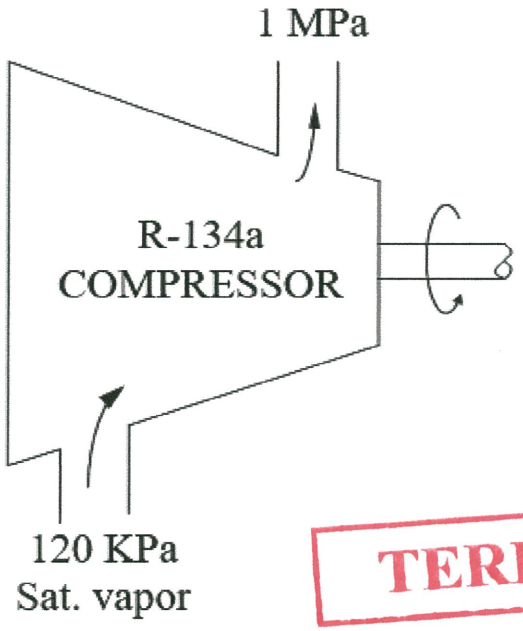

FIGURE Q5(c)