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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	THERMODYNAMICS I
COURSE CODE	:	BDA 20703
PROGRAMME	:	BDD
EXAMINATION DATE	:	JUNE / JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	**PART A**: ANSWER **TWO (2)** QUESTIONS **ONLY** FROM **THREE (3)** QUESTIONS. **PART B**: ANSWER **ALL** QUESTIONS.

THIS QUESTION PAPER CONSISTS OF **SIX** (6) PAGES

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

Q1 (a) Define the following terms relating with steam formation:

(i) Sensible heat of water (h_f),

(ii) Latent heat or hidden heat (h_{fg});

(iii) Dryness fraction (x); and

(iv) Total heat or enthalpy of wet steam (h).

(8 marks)

(b) A vessel having a capacity of 0.05 m^3 contains a mixture of saturated water and saturated steam at a temperature of 245°C. The mass of the liquid (m_f) present is 10 kg. Find the following:

(i) The pressure,

(ii) The mass;

(iii) The specific volume;

(iv) The specific enthalpy;

(v) The specific entropy, and

(vi) The specific internal energy.

(17 marks)

Q2 (a) Differential U tube manometer as shown as in **Fig. Q2 (a)** is to measure the pressure difference directly. Manometer equation the formula that relates the pressure difference $P_A - P_B$ to the difference in manometer Find the value of h1 using the manometer equation, where h is height and γ is specific gravity.

(10 marks)

(b) The water in a tank is pressurized by air, and a multifluid manometer as shown in **Fig. Q2 (b)** measures the pressure. The tank is located on a mountain at an altitude of 1400 m where the atmospheric pressure is 642.05 mmHg. Determine the air pressure in the tank if h_1 = 0.1 m, h_2 = 0.2 m, and h_3 = 0.35 m. Take the densities of water, oil, and mercury to be 1000 kg/m^3, 850 kg/m^3, and 13,600 kg/m^3, respectively.

(15 marks)

Q3 (a) Nozzle and diffuser are can be conveniently analysed as steady flow devices. What are the differences between nozzle and diffuser? Sketch the devices and explain the change in parameters crossing them.

(7 marks)

(b) A 5 m x 6 m x 8 m room is to be heated by an electric resistance heater placed in a short duct in the room. Initially, the room temperature is 15°C, and the local atmospheric pressure is 98 kPa. The room is losing heat steadily to the outside at a rate 200 kJ/min. A 200 W fan circulates the air steadily through the duct and the electric heater at an average mass flow rate at 50 kg/min. The duct can be assumed to be adiabatic, and there is no air leaking in or out of the room. If it takes 15 minutes for the room air to reach an average temperature of 25°C, find

(i) the power rating of electric heater; and
(ii) the temperature rise that the air experiences each time it passes through the heater.

(18 marks)

PART B: ANSWER ALL QUESTIONS.

Q4 (a) Heat is transferred to a heat engine from a furnace at a rate of 2.8 kW. If the rate of heat rejected by the heat engine is 2.1 kW, determine the net power output and thermal efficiency of this engine. Show the process in schematic diagram.

(7 marks)

(b) A heat pump comprises of four (4) basic components, uses R-134a as refrigerant and utilises total amount of the net power produced by the heat engine from **question Q4 (a)** to drive its compressor. During heat pump operation, its refrigerant enters the condenser at 770kPa and 38°C at a rate of

0.02 kg/s and leaves at constant pressure as a saturated liquid. For this heat pump conditions, you are required to:

(i) draw a schematic diagram for the heat pump system including its basic components complete with labelling of its components name, energies that enter and leave the system;
(ii) determine the rate of heat rejected by the condenser;
(iii) the rate of heat absorption from the surrounding;
(iv) the COP of the heat pump; and
(v) show the heat rejection process by the condenser on a *P-h* diagram complete with labelling of its pressure and enthalpy values on the diagram.

(18 marks)

Q5 (a) A heat engine receives reversibly 420 kJ/cycle of heat from a source at 327°C, and rejects heat reversibly to a sink at 27°C. There are no other heat transfers. For each of the four hypothetical amounts of heat rejected, in (i), (ii), (iii) and (iv) below, compute the cyclic integral of dQ /T. From these results show which case is irreversible, which reversible, and which impossible:

(i) 210 kJ/cycle rejected
(ii) 105 kJ/cycle rejected
(iii) 315 kJ/cycle rejected
(iv) 150 kJ/cycle rejected

(10 marks)

(b) Helium gas is compressed from 90 kPa and 30°C to 450 kPa in a reversible-adiabatic process. Determine the final temperature and the work done, assume that the process take place in;

(i) a piston cylinder device; and
(ii) a steady flow compressor.

(15 marks)

– END OF QUESTION –

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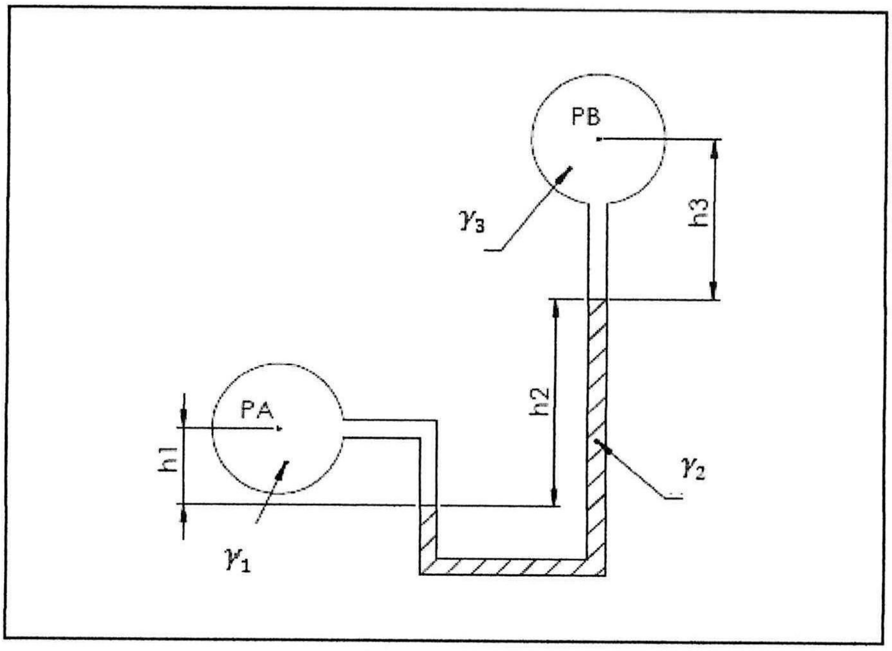

FIGURE Q2 (a)

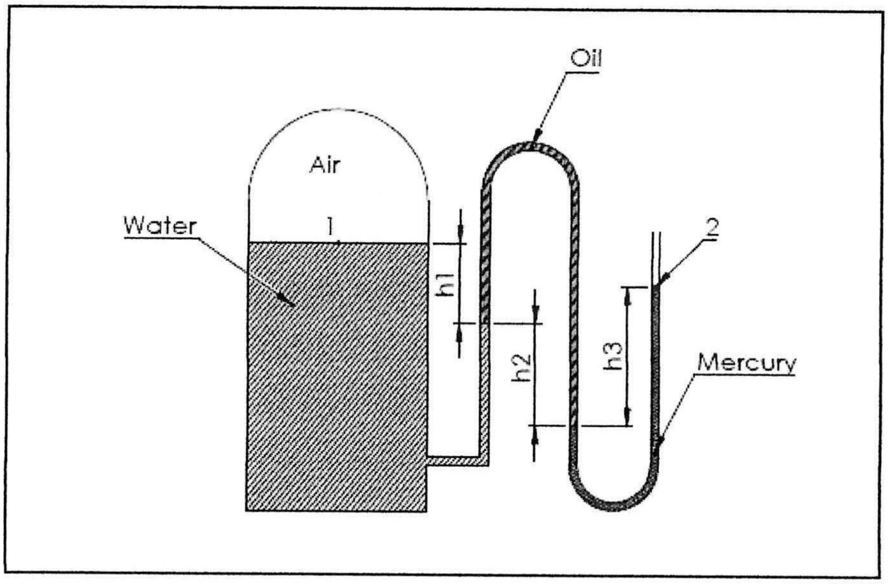

FIGURE Q2 (b)

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List of Equations

General Equations:

$$x = \frac{m_g}{m_T}$$

$$v = \frac{V}{m}$$

$$v = v_f + x(v_g - v_f)$$

$$u = u_f + x \cdot u_{fg}$$

$$h = h_f + x \cdot h_{fg}$$

$$s = s_f + x \cdot s_{fg}$$

Work boundary, $W_b = \int_1^2 P \cdot dV$

$$\Delta u = c_{V,avg}(T_2 - T_1)$$

$$\Delta h = c_{P,avg}(T_2 - T_1)$$

$$\dot{m} = \rho AV = \frac{AV}{v} = \frac{\dot{V}}{v}$$

$$ke = \frac{V^2}{2} \equiv \left[\frac{J}{kg}\right]$$

$$pe = gz \equiv \left[\frac{J}{kg}\right]$$

$Q_{net} = W_{net}$, For cyclic process in a closed system

Thermal efficiency, $\eta_{th} = \frac{W_{net,out}}{Q_{in}} = \frac{Q_H - Q_L}{Q_H}$

$$COP_{HP} = \frac{Q_H}{W_{net,in}} = \frac{Q_H}{Q_H - Q_L}$$

$$COP_R = \frac{Q_L}{W_{net,in}} = \frac{Q_L}{Q_H - Q_L}$$

Ideal Gas Equation of State, $PV = mRT$

$$c_P = c_V + R$$

$$k = \frac{c_P}{c_V}$$

Entropy:

Total heat transfer during internally reversible process,

$Q_{\text{int rev}} = \int_1^2 TdS$, general equation

$q_{\text{int rev}} = T_{\circ}(s_2 - s_1)$, in isothermal process

$$\delta W_{\text{int rev}} = PdV$$

$$\Delta S_{sys} = S_2 - S_1 = \int_1^2 \frac{\delta Q}{T} + S_{gen}$$

$$S_{gen} = \Delta S_{total} = \Delta S_{sys} + \Delta S_{surr} \geq 0$$

Entropy Change:

$\Delta s = c_{avg} \ln\left(\frac{T_2}{T_1}\right)$, For incompressible substances

For ideal gas (constant specific heat):

$$\Delta s = c_{P,\,avg} \ln\left(\frac{T_2}{T_1}\right) - R\ln\left(\frac{P_2}{P_1}\right)$$

$$\Delta s = c_{V,\,avg} \ln\left(\frac{T_2}{T_1}\right) + R\ln\left(\frac{v_2}{v_1}\right)$$

For ideal gas (variable specific heat):

$$\Delta s = s_2^{\circ} - s_1^{\circ} - R\ln\left(\frac{P_2}{P_1}\right)$$

During Isentropic:

$\left(\frac{T_2}{T_1}\right) = \left(\frac{v_1}{v_2}\right)^{k-1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$, at constant specific heat

$\left(\frac{P_2}{P_1}\right) = \left(\frac{P_{r2}}{P_{r1}}\right)$, at variable specific heat

$\left(\frac{v_2}{v_1}\right) = \left(\frac{v_{r2}}{v_{r1}}\right)$, at variable specific heat

Isentropic Efficiency:

$$\eta_T = \frac{\text{Actual turbine work}}{\text{Isentropic turbine work}} = \frac{w_a}{w_s} \cong \frac{h_1 - h_{2a}}{h_1 - h_{2s}}$$

$$\eta_C = \frac{\text{Isentropic compressor work}}{\text{Actual compressor work}} = \frac{w_s}{w_a} \cong \frac{h_{2s} - h}{h_{2a} - h}$$

$$\eta_N = \frac{\text{Actual KE at nozzle exit}}{\text{Isentropic KE at nozzle exit}} = \frac{V_{2a}^2}{V_{2s}^2} \cong \frac{h_1 - h}{h_1 - h}$$