Second Semester Examination
2020/2021 Academic Session

July 2021

KIT 258 – Unit Operations

Duration : 3 hours

Please check that this examination paper consists of **SEVEN (7)** pages of printed material before you begin the examination.

Instructions:

Answer **ALL** questions in **PART A** and only **TWO** questions in **PART B**.

Answer each question on a new page.

You may answer the questions either in Bahasa Malaysia or in English.

If a candidate answers more than two questions in Part B, only the answers to the first two questions in the answer sheet will be graded.

Part A (Answer ALL Questions).

1. (a) Briefly discuss the differences between direct and indirect contact type heat exchanges.

(6 marks)

(b) Fouling can occur in heat exchanges.

(i) Infer a cause for this occurrence.

(ii) Relate how fouling affects heat transfer and the performance of a heat exchanger.

(4 marks)

(c) Determine whether the water at each of the following states is a compressed liquid, a superheated vapor, or a mixture of saturated liquid and vapor:

(i) 10 MPa, 0.003 m^3kg^{-1}

(ii) 1 MPa, 190 ^oC

(iii) 200 ^oC, 0.1 m^3kg^{-1}

(iv) 130 ^oC, 200 kPa

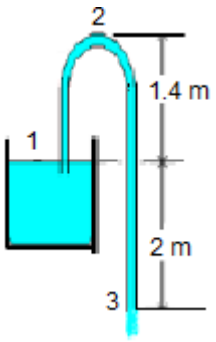
(v) 70 ^oC, 1 m^3kg^{-1}

(10 marks)

2. (a) A syphon is connected to a 75 mm diameter pipe and discharges water to the atmosphere, as shown in the figure below. The syphon has a similar diameter to the pipe. Neglecting any possible losses, calculate

(i) the velocity of flow and discharge

(ii) the absolute pressure at point 2.



(10 marks)

(b) Coal gasification consists of the chemical transformation of solid coal into gas. The heating values of coal differ, but the higher the heating value, the higher the value of the gas produced (which is essentially methane, carbon monoxide, hydrogen, etc.). The following coal has a reported heating value of 29,770 kJ kg^{-1} as received. Assuming that this is the gross heating value, show that net heating value is within 5 % of its gross value. Given, the latent heat of vaporization of water is 2,370 kJ kg^{-1}.

Component	Percent
C	71.0
H_2	5.6
N_2	1.6
S	2.7
Ash	6.1
O_2	13.0
Total	100.0

(10 marks)

3. (a) A venturimeter has a diameter of 150 mm at the inlet and 75 mm at the throat. The venturimeter is fixed to a pipe containing oil with a specific gravity of 0.9 and a volume flowrate of 1.9 m^3 min^{-1}. The reading shown by the U tube manometer connected to the venturimeter is 150 mm of mercury column.

(i) Prove that the ratio of the real discharge to theoretical discharge of the venturimeter is close to 1.

(ii) Justify your answer.

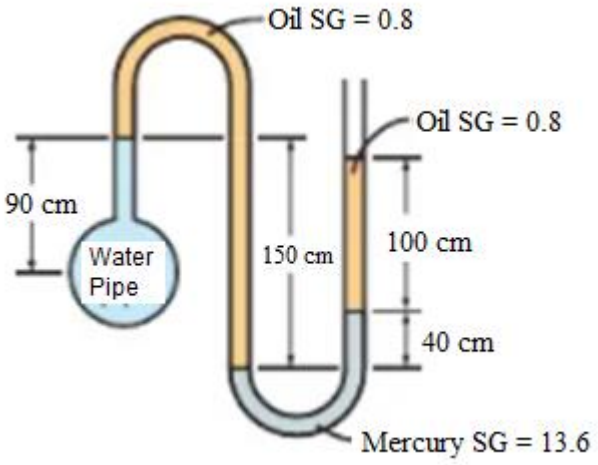
(10 marks)

(b) The solubility of manganous sulfate at 20 °C is 62.9 g/100 g H_2O. Calculate the amount of $MnSO_4.5H_2O$ which must be dissolved in 100 kg of water to give a saturated solution at 20 °C. The molecular weight for MnSO4.5H2O is 150.94 g mol^{-1}.

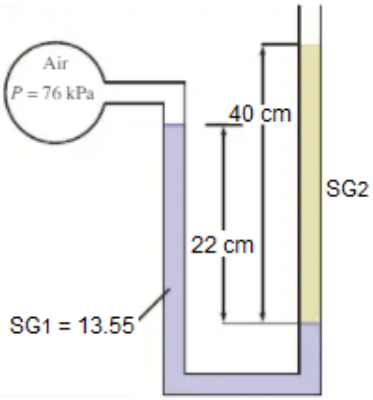
(10 marks)

Part B (Choose TWO Questions)

4. (a) A water pipe is connected to a double U tube manometer. Calculate the pressure at the centre of the pipe.



(b) Find the specific gravity, SG_2 for the following manometer.

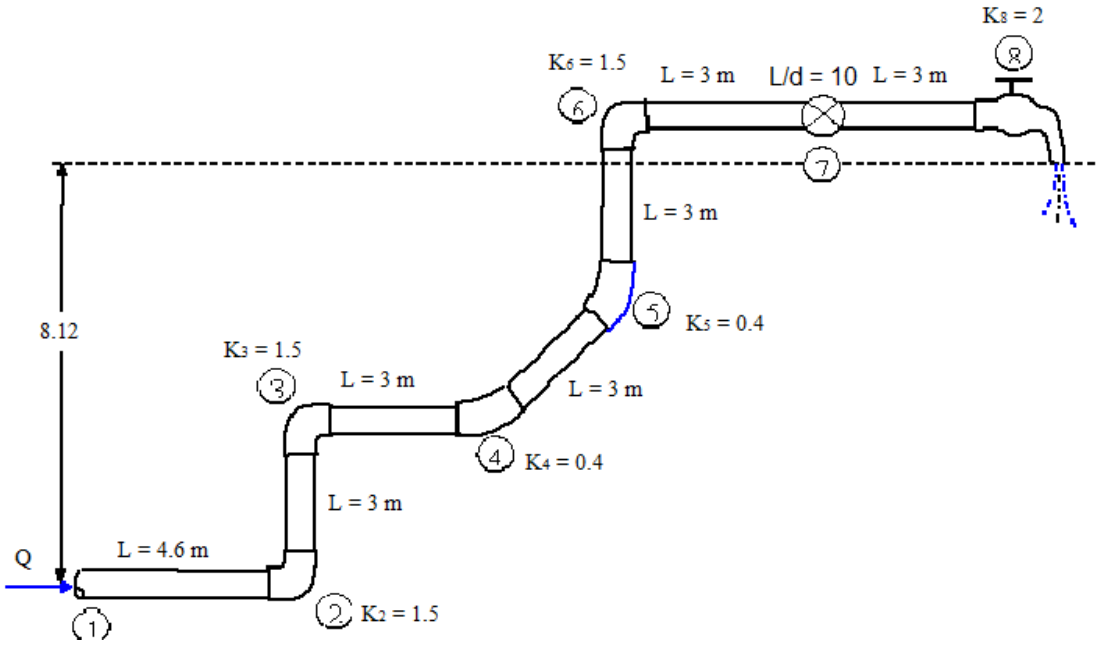


(10 marks)

(c) A natural gas consisting entirely of methane (CH_4) is burned with an oxygen-enriched air of composition 40 % O_2 and 60% N_2. The Orsat analysis of the product gas as reported by the laboratory is CO_2 = 20.2 %, O_2 = 4.1 %, N_2 = 75.7 %. Some water was evaporated in the process. Justify the validity of the reported analysis.

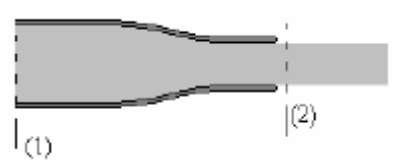
(10 marks)

5. Water flows from the basement of a house to its second floor via a 2 cm diameter copper pipe. The water has a volume flowrate of 0.8 L s^{-1} and exits through a faucet with a diameter of 1.3 cm and loss coefficient, K of 2. The K values of the bends K_2, K_3 and K_6 are 1.5 respectively while bends K_4 and K_5 are 0.4 respectively. The globe valve at point 7 has an L/d = 10. Given that the friction factor of the copper pipe is, f = 0.0215, compare the gauge pressure at point 1 with and without taking the head loss into consideration.



(20 marks)

6. (a) The figure below shows a horizontal nozzle discharging into the atmosphere. The inlet has an area of 600 mm^2 while the exit at point 2 has an area of 300 mm^2. Assuming no loss in energy, calculate the volume flowrate when the gauge pressure is 400 kPa at the inlet.



(7 marks)

(b) A woman goes to a supermarket to purchase a piece of steak for dinner. She finds that a 12-oz steak costs RM 3.15. In another nearby supermarket, she finds that a 320 g piece of steak with identical quality costs RM3.30. Given that $1lb_m$ = 16 oz, determine which stake she should buy.

(3 marks)

(c) A glass window with an area of 0.557 m^2 is installed in the wooden outside wall of a room. The wall dimensions are 2.44 m x 3.05 m. The wood has a *k* of 0.1505 $Wm^{-1}K^{-1}$ and is 25.4 mm thick. The glass is 3.18 mm thick and has a *k* of 0.692. The inside room temperature is 299.9 K and the outside air temperature is 266.5 K. The convection coefficient h_i, on the inside wall of the glass and the wood is estimated as 8.5 $Wm^{-2}K^{-1}$; the outside h_o is also estimated as 8.5 $Wm^{-2}K^{-1}$ for both surfaces. Calculate the heat loss through the wooden wall, through the glass, and the total heat loss.

(10 marks)

7. (a) The following entries are taken from a data table for saturated methyl chloride:

State	T (^oF)	P (psia)	v ($ft^3\ lb_m^{-1}$)	h (Btu lb_m^{-1})
Liquid	-40	6.878	0.01553	0.000
Vapor	0	18.90	4.969	196.23
Vapor	50	51.99	1.920	202.28

(i) Determine the reference state used to generate the given enthalpies.

(ii) Show that the transition of saturated methyl chloride vapor from 50 ^oF to 0 ^oF will lead to lower internal energy. Given 1.987 Btu = 10.73 ft^3psia.

(iii) Justify your assumption made in solving part (ii) regarding the effect of pressure on specific enthalpy.

(10 marks)

(b) (i) Determine the vapor pressure, specific internal energy, and specific enthalpy of saturated vapor at 133.5 ^oC.

(ii) Determine specific volume, specific internal energy, and specific enthalpy relative to liquid water at the triple point, and its dew point for water at 400 ^oC and 10 bar.

(iii) Show that *u* and *h* for superheated steam depend strongly on temperature and slightly on pressure.

(10 marks)

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