UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	PLANT ENGINEERING DESIGN
COURSE CODE	:	BNL 30803
PROGRAMME	:	BNL
DATE	:	JUNE/ JULY 2016
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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

Q1 Oil is transfered from TK 101 to TK 201 by means of a centrifugal pump as shown in **Figure Q1**. Valves V1 and V3 are fully open gate valve ($k = 0.15$). The loss coefficient of the check valve, V2, is $k = 2$. The loss coefficient for 90° standard elbow is $k = 0.8$. The tank outlet and inlet have a loss coefficient of 0.5 and 1.0, respectively. The friction factors of the pipe line upstream (higher pipe diameter) and downstream to the pump are at 0.02 and 0.04, respectively. The oil density is 890 kg/m^3 and the gravity constant is 9.8 m/s^2.

(a) By applying the energy balance on the stream line at point 0 to 1, formulate the pressure increase, Δp_{pump}, required by the oil from the pump to maintain a certain flowrate.

(7 marks)

(b) Express the system equation in the following form:

$$h_a = \Delta h + K\dot{V}^2$$

h_a: actual head; K: a constant that depends on the pipe sizes and lengths, friction factors, and minor loss coefficients; Δh: change in elevation head; and $\dot{V}$: Volume flow rate [m^3/min].

(7 marks)

(c) Calculate the values of each h_a for the flow rates at $\dot{V} = 0.0, 0.2, 0.4, 0.6, 0.8,$ and 1.0 [m^3/min]. Plot these data on **Figure Q1 (c)**.

(5 marks)

(d) Determine the actual head, h_a, the required power of pump P 101, $\dot{W}_{\text{pump}}$ and its efficiency, η, for this particular oil transfer system. Power of pump :$\dot{W} = \rho g h_a \times \dot{V}$

(6 marks)

Q2 An incomplete piping and instrumentation diagram (P & ID) for oil transfer system is shown in **Figure Q2**. You shall complete the initial P & ID by aswering the following questions:

(a) Furnish the P & ID by installing associated pressure gauges and temperature elements on tanks TK 101 and TK 201. Use tagging conventions.

(7 marks)

(b) The temperature of oil in TK 101 shall be kept at a certain set value. Steam is used to control the oil temperature by regulating the steam flow rate to the tank. The field instrument uses the same loop diagram. All the control devices are located in the control room and the instrument indicators are attached locally. Glove valve is used for bypass line. All the actuated valves are operated by an instrument air. Design and install an appropriate control system for the TK 101 on the P & ID drawing to achieve this purpose.

(10 marks)

(c) To avoid oxygen accumulation in tanks TK 101 and TK 201, a purging system of nitrogen must be provided. Install purging lines on the diagram.

(4 marks)

(d) Place a pressure relief valve for each tank to hindern over pressure.

(4 marks)

Q3 Methane is mixed with air at 20% excess over stoichiometric requirement and undergoes combustion in a burner at 2 bar. The inlet gases are at 40 °C and the effluent stream is at 1000 °C. The heat capacities and the standard heat of combustion for the compounds are given in **Table Q3**. Air is assumed to be 21% oxygen and 79% nitrogen.

(a) Write the relevant stoichiometric combustion for complete oxidation of methane.

(4 marks)

(b) Calculate the actual amount of oxygen.

(4 marks)

(c) Determine the standard heat of reaction for the complete combustion.

(5 marks)

(d) By applying the energy balance, determine the heat released by the reaction.

(8 marks)

(e) Justify why the heat released by the reaction is less than that of the enthalpy of the reaction.

(4 marks)

Q4 Heat exchanger is an important plant equipment for heat transfer between hot fluid and cold fluid.

(a) Sketch a shell–tube heat condenser by showing the inlets and the associated outlets.

(6 marks)

(b) Plot the temperature profiles for parallel and counter current flows.

(8 marks)

(c) Formulate the definition of logarithmic mean temperature difference (LMTD) based on the your graphs in item (b).

(4 marks)

(d) Water is used to cool alcohol flowing in the inner pipe of a double–pipe condenser. The inner pipe is made of 25 mm diameter Schedule 40 steel pipe. The thermal conductivity of steel is 45 W/(m °C). The individual coefficients and fouling factors are given in **Table Q4 (d)**. Determine the overall coefficient based on the outside area of the inner pipe.

(7 marks)

– END OF QUESTIONS –

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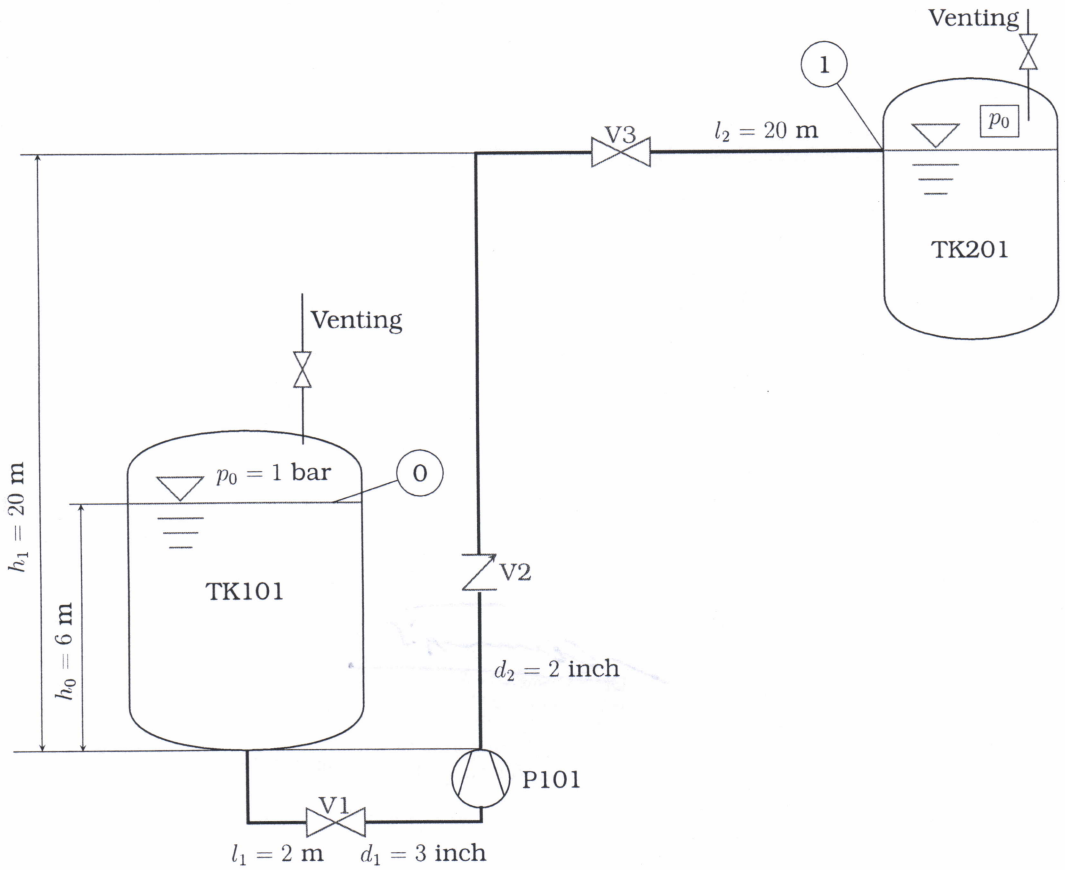

Figure Q1

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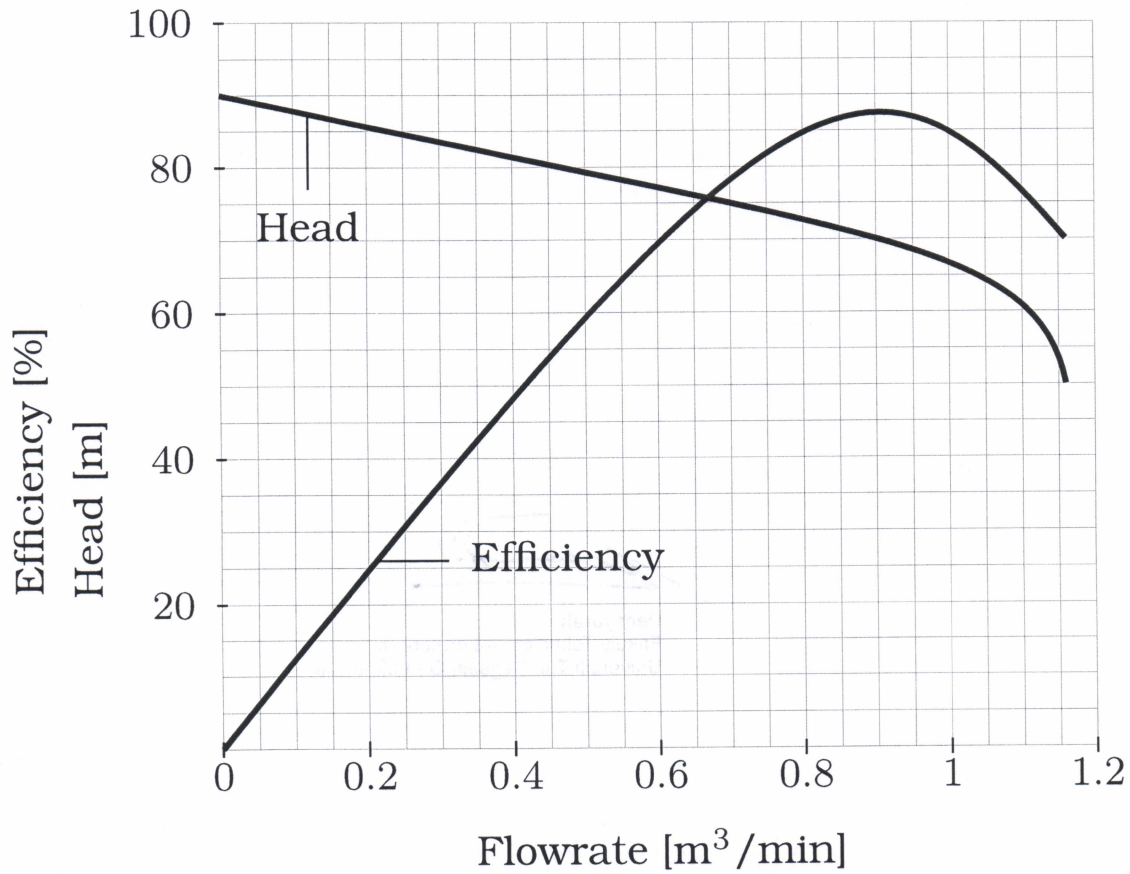

Figure Q1 (c)

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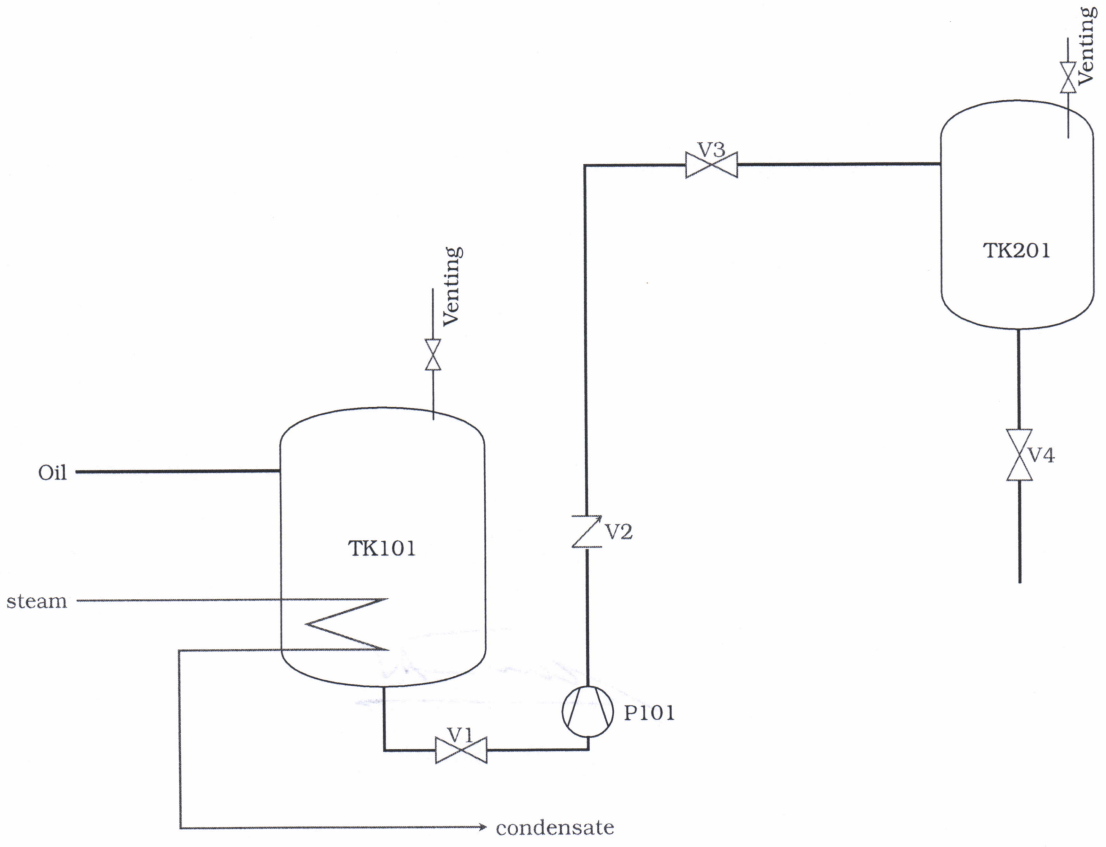

Figure Q2

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Table Q3

Compound	c_p [J/mol K]	$H°$ [J/mol]
CH_4	55.42	-75520
O_2	32.53	0
N_2	30.37	0
CO_2	48.05	-393509
H_2O	36.94	-241818

Table Q4 (d)

Parameter	**Coefficient** [W/m^2 °C]
Alcohol coefficient, h_i	1,020
Water coefficient, h_o	1,700
Inside fouling factor, h_{di}	5,680
Outside fouling factor, h_{do}	2,840

Equations for the overall coefficients based on outside and inside area:

$$U_o = \frac{1}{\frac{D_o}{D_i h_{di}} + \frac{D_o}{D_i h_i} + \frac{x_w}{k_w}\frac{D_o}{D_L} + \frac{1}{h_o} + \frac{1}{h_{do}}} \quad (1)$$

$$U_i = \frac{1}{\frac{D_i}{D_o h_{do}} + \frac{D_i}{D_o h_o} + \frac{x_w}{k_w}\frac{D_i}{D_L} + \frac{1}{hi} + \frac{1}{h_{di}}} \quad (2)$$

Diameter and wall thickness of 25 mm diameter Schedule 40 pipe:

$D_i = 0.0874$ ft $\quad D_o = 0.1096$ ft $\quad x_w = 0.0111$ ft