QUESTION 1 (20 marks; CLO4, PLO5, C3 – Application; WP1, WP4; WK3, WK4, WK5, WK6)

In this simulation, use Chao-Seader fluid package. Based on information given in Table 1, answer all the following questions.

Table 1: Feed stream information

Feed Components	**Composition**	**Desired Purity (%)**
Cyclopentane	0.3	99.0
Benzene	0.5	
Toluene	0.2	
Pressure (kPa)	101.3	
Feed condition	Saturated Liquid	
Flowrate (kmol/h)	1000	

a) Based on information given, list all four variables defined for this case.

(5 marks)

b) Classify the phase of this mixture.

(5 marks)

c) Show that how to change this mixture into a vapour phase without adding any heating-related equipment.

(5 marks)

d) Classify the boiling temperature of this mixture? Screenshot the feed information.

(5 marks)

QUESTION 2 (20 marks; CLO4, PLO5, C3 – Application; WP1, WP4; WK3, WK4, WK5, WK6)

In this simulation, use Peng-Robinson fluid package. Based on information given in Table 2, design and simulate a system that has the final conditions as shown in Table 3. Then, answer all the following questions.

Table 3: Feed stream information

Feed Components	Composition	Desired Purity (%)
Benzene	0.7	96.5 %
Toluene	0.3	
Pressure (kPa)	101.3	
Temperature (°C)	150	
Flowrate (kmol/h)	1000	

Table 3: Outlet stream information

Feed Components	Composition	Desired Purity (%)
Benzene	0.7	96.5 %
Toluene	0.3	
Pressure (kPa)	303.9	
Temperature (°C)	70	
Flowrate (kmol/h)	1000	

a) According to Table 1, classify the phase of this mixture.

(5 marks)

b) According to Table 2, classify the phase of this mixture.

(5 marks)

c) Briefly show the process by manually drawing the design of this process. Label all information for all streams.

(5 marks)

d) Examine the design in (c) by simulating the process using Aspen HYSYS. Screenshot the simulation environment.

(5 marks)

QUESTION 3 (30 marks; CLO1, PLO2, C4 – Analysis; WP1, WP4; WK3, WK4, WK5, WK6)

In this simulation, use Peng-Robinson fluid package. Hydrogen is predominantly generated from the reaction amongst methane and steam. Natural gas is sent to the primary reformer for steam reforming, where the superheated steam is fed into the reformer with the methane at 639.7 °C in the presence of a nickel catalyst where methane is converted to hydrogen, carbon dioxide and little amounts of carbon monoxide based on Equations (1) and (2).

$$CH_4 + 2H_2O \xrightarrow{50\ \%} CO_2 + 4H_2 \qquad (1)$$

$$CH_4 + H_2O \xrightarrow{20\ \%} CO + 3H_2 \qquad (2)$$

a) How many components required in this simulation? List all of them.

(5 marks)

b) Choose the Reaction Set-1 for Reactions (1) and (2). Screenshot these reactions (Rxn-1, Rxn-2) and Reaction Set-1.

(5 marks)

c) Examine the vapour fraction of Methane stream (F = 1000 kmol/h, T = 371 °C, P = 3345 kPa) and Steam stream (F = 3000 kmol/h, T = 639.7 °C, P = 3345 kPa). Screenshot these two streams by showing the stream conditions.

(5 marks)

d) Install a conversion reactor as a Primary Reformer and connect it with Methane stream and Steam stream. Name the top stream as "Top Product" and the bottom stream as "Bottom Product". Screenshot the reactor.

(5 marks)

e) Screenshot the "Top Product" compositions in molar flowrate. Analyse the percentage conversion of Methane.

(5 marks)

QUESTION 4 (30 marks; CLO1, PLO2; C4 – Analysis; WP1, WP4; WK3, WK4, WK5, WK6)

In this simulation, use Peng-Robinson fluid package. Based on information given in Table 4, answer all the following questions.

Table 4: Feed stream information

Feed Components	**Composition**	**Desired Purity (%)**
n-Pentane	0.3	99.0
Cyclopentane	0.4	
Benzene	0.1	
Toluene	02	
Pressure (kPa)	101.3	
Temperature (°C)	120	
Flowrate (kmol/h)	1000	

a) Briefly explain the definition of direct sequence. Manually draw the direct sequence for this Feed by showing corresponding component at all product streams.

(5 marks)

b) Briefly explain the definition of indirect sequence. Manually draw the indirect sequence for this Feed by showing corresponding component at all product streams.

(5 marks)

c) Simulate the direct sequence in (a) using Short-Cut distillation column. Screenshot the Aspen HYSYS simulation.

(5 marks)

d) Analyse the total energy required for this direct sequence.

(5 marks)

e) Simulate the indirect sequence in (b) using Short-Cut distillation column. Screenshot the Aspen HYSYS simulation.

(5 marks)

f) Analyse the total energy required for this indirect sequence.

(5 marks)