BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF CHEMISTRY

Programme: HBScCHT Part 1.2

JUN 2025

Course code: CH116 Fundamentals of Chemical Engineering

Duration: 2 Hours

ANSWER QUESTION ONE AND ANY TWO FROM SECTION A AND TWO FROM SECTION B. EACH QUESTION CARRIES TWENTY MARKS

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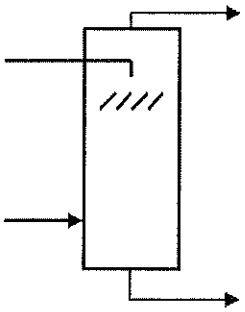
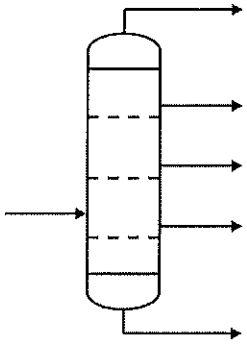
Q1 a) Yellow phosphorous can be produced through reduction of calcium phosphate with carbon and silicon dioxide according to the following reaction:
$10C + 2Ca_3(PO_4)_2 + 16SiO_2 \rightarrow 10CO + P_4 + 6CaSiO_3$
How many tons of phosphorus (P_4) can be produced from 200 tons of calcium phosphate.

[5 Marks]

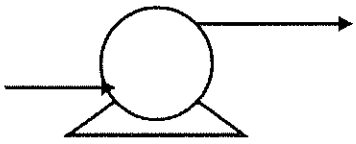
b) What is the meaning of the following process symbols?



i.



ii.



iii.

[2x3 Marks]

c) Briefly explain why a material balance is important to a chemical engineer.

[4 Marks]

d) Draw a well-labelled diagram of a shell and tube heat exchanger. **[5 Marks]**

SECTION A: ANSWER ANY TWO QUESTIONS

Q2 a) Chemical process flow diagrams may be labeled with symbols representing utility streams. What is the meaning of the following symbols for utility streams?

(i) **bfw,** (ii) **lps,** (iii) **cw,** (iv) **fw** **[4 Marks]**

b) A pure stream of NaOH and water are mixed on a continuous basis to prepare an aqueous solution at 20 mol% NaOH.
   i) Draw a flow chart for the mixing process
   ii) What is the rate of each stream required to prepare a 100 mol/h.

[3+4 Marks]

c) The feed to a distillation column contains 36% benzene (B) by weight, and the remainder toluene (T). The overhead distillate is to contain 52% benzene by weight, while the bottom is to contain 5% benzene by weight. Draw a flow diagram for the distillation process. Calculate the percentage of benzene in the feed that is contained in the distillate, and the percentage of the total feed that leaves as distillate.

[7 Marks]

Q3 a) What is the function of the following streams in a multi-process?
   (i) Recycle
   (ii) By-pass
   (iii) Purge system

[4+2+2 Marks]

b) For the following cases, determine which reactant is limiting and which is in excess as well as the percent for that component
   i) 2 mol of nitrogen (N_2) reacts with 4 mol of hydrogen (H_2) to form ammonia (NH_3) via the reaction
   $N_2 + 3H_3 \rightarrow 2NH_3$
   ii) 64 g of methanol (CH3OH) react with 0.5 mol of oxygen (O_2) to form formaldehyde:
   $CH_3OH + ½O_2 \rightarrow HCHO + H_2O$

[2x3 Marks]

c) What are the Reynolds numbers for:
   (i) Turbulent flow
   (ii) Laminar flow and
   (iii) Plug flow

[2x3 Marks]

Q4 a) What is the function baffles in a shell and tube heat exchanger? **[2 Marks]**

b) Using illustrations, explain the classification of heat exchangers according to:
   i. Flow arrangement.
   ii. Compactness.

[10 Marks]

c) State the first four steps in the design of a heat exchanger. **[4 Marks]**

d) Explain the causes of fouling in heat exchangers. **[4 Marks]**

SECTION B: ANSWER ANY TWO QUESTIONS

Q5 a) What are the two basic modes of operating a distillation column? **[2 Marks]**

b) With the help of illustrations, explain the functioning of:
(i) Sieve trays
(ii) Valve trays

[2x5 Marks]

c) Describe how Thiele-McCabe graphical method can be used in the design of binary distillation columns. **[8 Marks]**

Q6 a) With the help of illustrations, explain the functioning of:
i. Kettle re-boiler
ii. Internal re-boiler

[2x5 Marks]

b) How are the following distillation processes carried out?
(i) Azeotropic distillation
(ii) Extractive distillation.

[2x3 Marks]

c) Weeping may be experienced during a distillation operation. How does this affect the efficiency of distillation? **[4 Marks]**

Q7 a) Draw a diagram to illustrate a:
i. Bubble column
ii. Multi-tubular reactor

[2x3 Marks]

b) Derive a design equation for a batch reactor. **[6 Marks]**

c) The exothermic reaction of stillbene (A) to form the economically important trospophene (B) and methane (C), that is,

$A \rightarrow B + C$

was carried out adiabatically and the following data recorded:

X	0	0.2	0.4	0.45	0.5	0.6	0.8	0.9
$-r_A$(mol/dm^3·min)	1.0	1.67	5.0	5.0	5.0	5.0	1.25	0.91

The entering molar flow rate of A was 300 mol/min. Calculate CSTR volume to achieve 40% conversion **[8 Marks]**

END OF EXAM