NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING

DEPARTMENT OF CHEMICAL ENGINEERING

CHEMICAL AND ENVIRONMENTAL PROCESS ENGINEERING II

TCE 7101

Examination Paper

DECEMBER 2024

This examination paper consists of four (4) pages including the cover page

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: NONE

Examiner's Name: Prof. G Danha, Eng S Ncube

INSTRUCTIONS

1. Answer **ALL** questions in **SECTION A**
2. Answer **ANY TWO** questions in **SECTION B**
3. Each question carries 25 marks
4. Use of calculators is permissible

MARK ALLOCATION

QUESTION	MARKS
A1	**25**
A2	**25**
B1	**25**
B2	**25**
B3	**25**
TOTAL ATTAINABLE MARK	**100**

SECTION A

ANSWER ALL QUESTIONS (A1 and A2)

QUESTION A1

A1.1 Explain the **effects of malodorous substances, volatile organic compounds and particulates** on the environment and human health. **[8]**

A.1.2 Why is the **Air Pollution Index (API)** designated in levels and which gases are typically of concern? **[6]**

A.1.3 Air Quality Legislation is essential and a mandatory statutory instrument. What are the important aspects of the Zimbabwean **Atmospheric Pollution Prevention Act**? **[5]**

A.1.4 EMA Limits are divided into categories. What are those categories and explain the limits for the following gaseous pollutants: **[6]**

a) Particulate Matter (PM)
b) NOx
c) SO_2
d) NH_3

QUESTION A2

A1.1 Which two Continuous Emission Monitoring Systems **(CEMS)** technologies are used to monitor flue gases emitted from stacks? Include the diagrams, disadvantages and advantages of each system. **[10]**

A1.2 What **analytical/detection** methods and scientific basis principles are used **internally** in CEMS Technologies to identify each of the following gas discharges from a stack: **[15]**

a) SO_2
b) CO_2
c) O_2
d) H_2S
e) NH_3

SECTION B

ANSWER ANY TWO (2) QUESTIONS

QUESTION B1

B1.1 Describe the difference between super-adiabatic and sub-adiabatic conditions in the vertical dispersion of pollutants. **[12]**

B1.2 In the movement of atmospheric pollutants the Gaussian Dispersion Model (GDM) is relevant. Describe how the model is applied and use also the aid of diagrams. **[13]**

QUESTION B2:

B.2.1 A process for producing highly valuable permeate is depicted in Fig 1.

a) Which five (5) process improvements can be made? In your explanation, also use diagrams to re-draw the optimised process flow chart. **[18]**

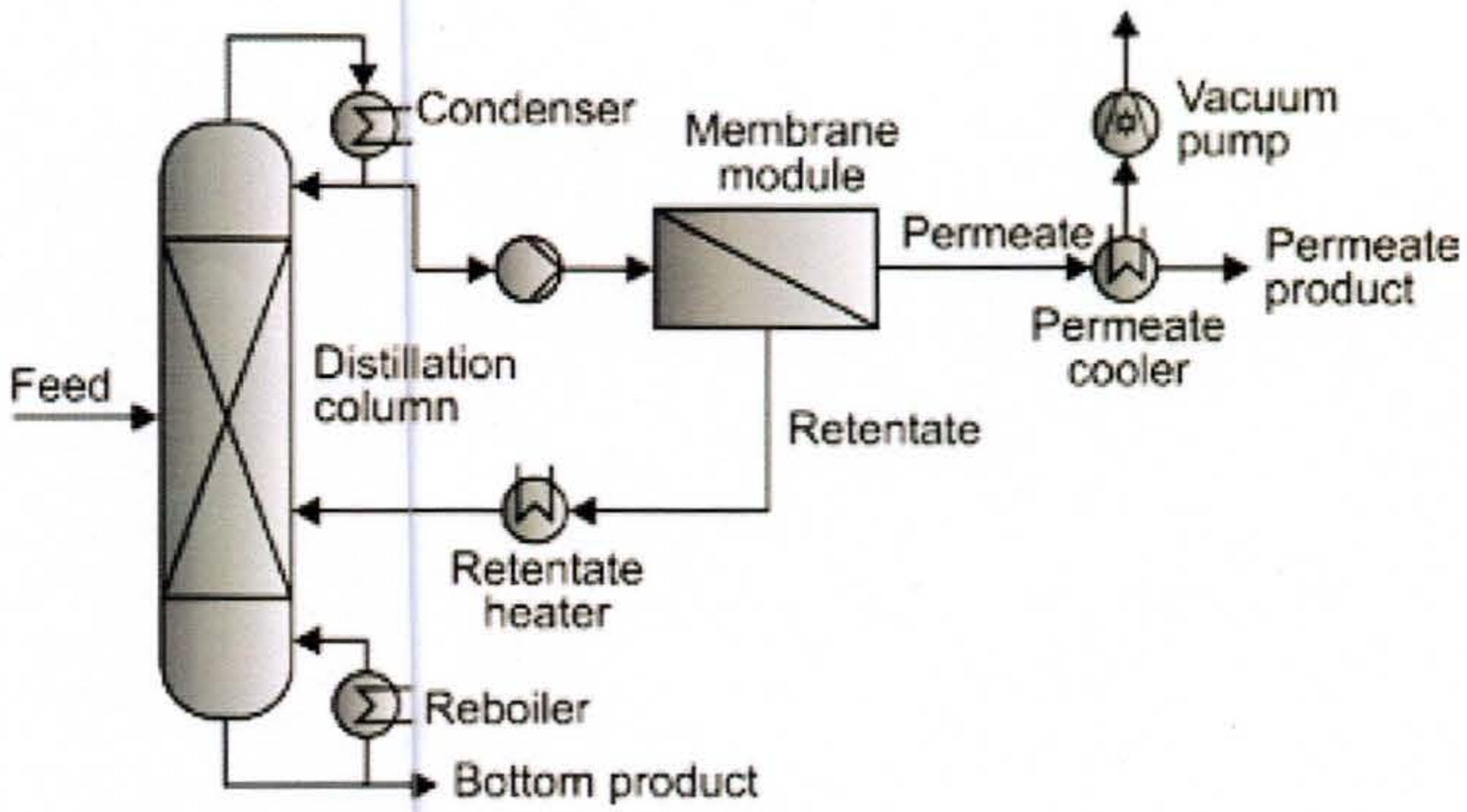

Fig 1. Permeate production process using steam reforming

B.2.2 A power plant has a stack with a diameter of 2.1 m and emits gases with a stack velocity of 16 m/ and a heat emission rate of 4800 kJ/s.The wind speed is 4.5 m/s. Estimate the plume rise. If the stack has a geometric height of 42 m, what is the effective stack height? **[7]**

$$\Delta h = 0.35\frac{V_s d}{u} + 2.64\frac{Q_h^{0.5}}{u}$$

QUESTION B3:

B.3.1 State and explain **3 characteristics of gaseous waste** which can be used for the selection of an effective technology for the removal/reduction of particulates from gaseous stream. **[6]**

B.3.2 Plasma incineration is one of the technologies used to treat volatile organic pollutants from Gaseous waste.

a) Describe in detail the functionality of the plasma incinerators. As part of the description, also use diagrams for clarifications. **[8]**

b) What are the advantages and disadvantages of this technology as well as the operational problems that are encountered? **[6]**

B.3.3 In the collection of air samples prior to analysis, the **Condensation in Trap** method is used. Explain three (3) mechanisms that can be applied to achieve the collection of the sample material. **[5]**

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End of Paper