MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING, SCIENCE AND TECHNOLOGY

DEPARTMENT: CHEMICAL AND PROCESSING ENGINEERING

MODULE: PLANT AND EQUIPMENT DESIGN

CODE: CHEP321

SESSIONAL EXAMINATIONS
JUNE 2023

DURATION: 3 HOURS

EXAMINER: MISS H TOM

INSTRUCTIONS

1. *Choose **any four** questions*
2. *Each question carries 25 marks*
3. *Start a new question on a fresh page*
4. *Total marks 100*
5. *Calculators required*

QUESTION ONE

(a) List 5 basic plant utilities in the chemical industry. [5]

(b) There are five generally accepted classifications of capital cost estimates that are most likely to be encountered in the process industries. List and explain them in their order of accuracy. [20]

QUESTION TWO

(a) What is the Chemical Engineering Plant Cost Index (CEPCI) used for, and what does it measure? [2]

(b) State three factors would determine the capital cost of a piece of equipment such as a heat exchanger at a given time? [3]

(c) Recently a cast iron leaf pressure filter with 100 ft^2 was purchased for clarifying an inorganic liquid stream for \$15 000. In a similar application, the company will need a 450 ft^2 cast iron leaf pressure filter. The size exponent for this type filter is 0.6. Estimate the purchased price of the 450 ft^2 unit. [4]

(d) The purchased cost of a heat exchanger of 500 m^2 area in 1992 was \$25 000.

Table 1 shows the CEPCI and Marshall and shift index for the year 1992 and 2006.

Table 1

Year	**Chemical engineering plant cost index (CEPCI)**	**Marshall and shift index**
1992	358	943
2006	500	1302

(i) Estimate the cost of the same heat exchanger in 2006 using CEPCI and Marshall and shift index

(ii) Compare the results. [8]

(e) You have been hired as a consultant to a legal firm. Part of your assignment is to determine the size of a storage tank purchased in 1978, before computerization of records. Many records from this era were destroyed in a fire. The tank was replaced every 10 years, and the sizes have changed due to plant capacity changes. **Table 2**

shows the Capacity (10^3) gal, purchased cost ($) and CEPCI for the years 1978, 1988 and 1998.Estimate the original capacity of this vessel.

Table 2

Year	Capacity (10^3) gal	Purchased cost ($)	CEPCI
1978	?	35 400	219
1988	105	45 300	343
1998	85	45 500	390

[8]

QUESTION THREE

(a) Describe and explain the term HAZOP Study as it is used in plant design. [5]

(b) The reaction below is exothermic. A cooling system is provided to remove the excess energy of reaction. In the event of cooling function is lost, the temperature of reactor would increase. This would lead to an increase in reaction rate leading to additional energy release. The result could be a runaway reaction with pressures exceeding the bursting pressure of the reactor. The temperature within the reactor is measured and is used to control the cooling water flow rate by a valve.

Using the reactor system in **Fig. 1** to perform a HAZOP study using the guide words No, Reverse, More, As well as and Other than. [20]

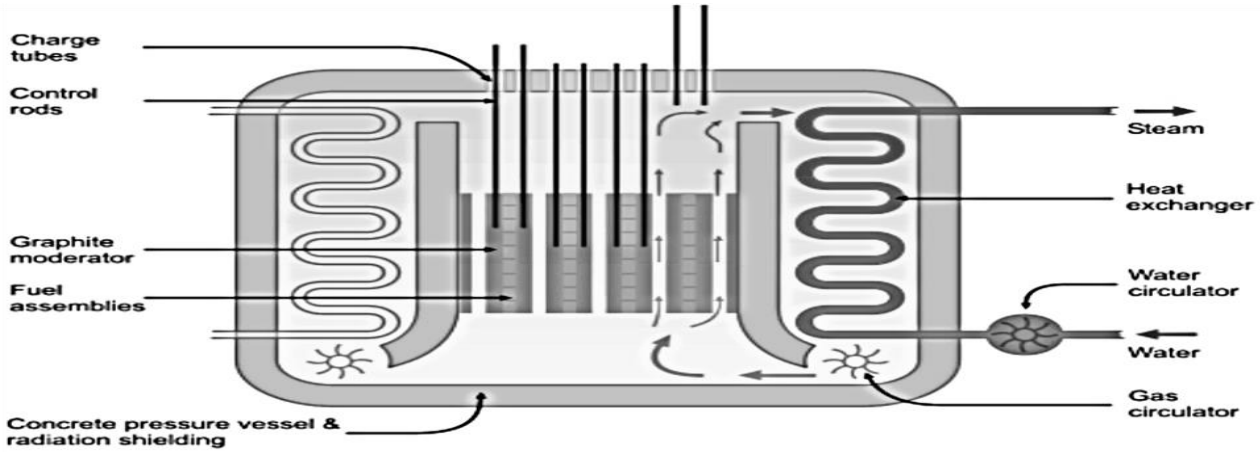

Fig. 1

QUESTION FOUR

(a) Considering the unit operation **P-101A/B** displayed in **Fig. 2**, describe what each number or letter represents. [5]

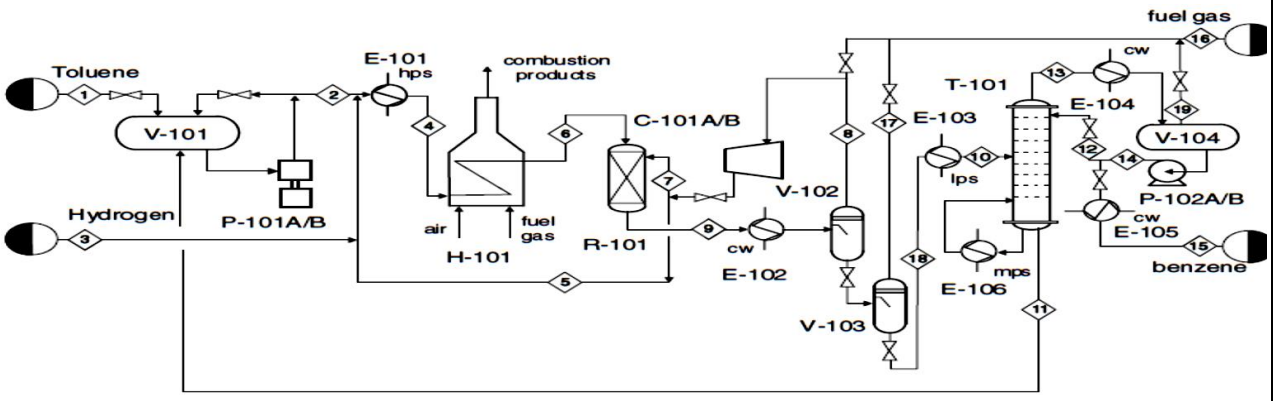

Fig.2

(b) Using **Table 3**, estimate the fixed capital investment for a 1500 ton/day ammonia plant using the turnover ratio. The current gross selling price of ammonia is $150/ton. The plant will operate at a 95% stream time.

Table 3

Product	Turnover Ratio
Acetic acid	1.70
Acrylonitrile	1.55
Ammonia	0.65
Ammonium sulfate	3.82
Benzaldehyde	1.00
Benzene	8.25
Butadiene	1.68
Butanol	1.10
Carbon tetrachloride	1.00
Ethylene dichloride	0.51
Sodium carbonate	0.39
Styrene	5.21
Sulfuric acid	0.63
Urea	2.36
Vinyl chloride	3.40

[6]

(c) Determine the capital cost for a major expansion to a fluid processing plant that has a total purchased equipment cost of $7 200 000. [4]

(d) Explain in detail **two** types of Pictorial flow sheets your choice. [10]

QUESTION 5

(a) Explain the purpose of pinch technology in major chemical plant industries. [5]

(b) Design a Heat Exchanger using the data below:

Syngas is on the tube sides
Water is on the shell side
Flow rate of syngas= 1318.914 kg/h
Flow rate of water = 2083.773 kg/h
Initial Temperature of syngas = 800 ^{o}C
Final temperature of syngas = 500 ^{o}C
Initial temperature of water = 25 ^{o}C
Final temperature of water = 98.55 ^{o}C
Specific heat capacity of syngas = 4.569 kJ/ kg.^{o}C
Specific heat capacity of water = 4.18 kJ/ kg.^{o}C

[20]

END OF EXAMINATION