



# NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCE

DEPARTMENT OF APPLIED CHEMISTRY

PRINCIPLES OF PROCESS ENGINEERING

SCH 2218

Supplementary Examination Paper

August 2015

This examination paper consists of 5 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: Graph paper

Examiner's Name: Mr. B. Nyoni

## INSTRUCTIONS

1. Answer all questions in Section A and any other three questions from Section B
2. Each question carries 20 marks
3. Show steps clearly in any calculation
4. Start the answers for each question on a fresh page
5. Use of calculators is permissible

## MARK ALLOCATION

QUESTION	MARKS
1.	20
2.	20
3.	20
4.	20
5.	20
<b>TOTAL POSSIBLE MARKS</b>	<b>100</b>

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## **SECTION A**

1 (a) Define the following terms:

(i) Chemical/Process Engineering

(ii) Transport phenomena

(iii) Unit Operations

[9 marks]

(b) Explain the difference between Newtonian and Non-Newtonian fluids and give an example of each. [5 marks]

(c) In Junior Certificate Science, *Diffusion* was defined as the movement of molecules from a region of high, to a region of low concentration. Using analogy, define the following terms

(i) fluid flow

(ii) heat transfer

[6 marks]

2 (a) What do you understand by the term 'a dimensionally consistent equation'. [3 marks]

(b) Check the dimensional consistency of the following empirical equation for a heat-transfer coefficient.

$$h_i = 0.023G^{0.8}k^{0.67}c_p^{0.33}D^{-0.2}\mu^{-0.47}$$

given  $h_i$  = heat transfer coefficient (W/m<sup>2</sup>.°C)

G = mass velocity (kg/s.m<sup>2</sup>)

k = thermal conductivity (W/m.°C)

$c_p$  = specific heat (J/g.°C)

D = diameter

$\mu$  = absolute viscosity (kg/m.s)

[14 marks]

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(b) What is the mass velocity, given the following data:

$$k = 0.12 \text{ W/m}\cdot\text{°C}$$

$$c_p = 4.2 \text{ J/g}\cdot\text{°C}$$

$$D = 0.11 \text{ m}$$

$$\mu = 0.034 \text{ kg/m}\cdot\text{s}$$

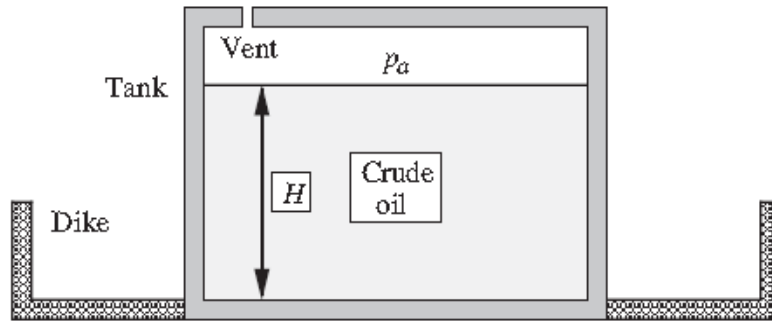
$$h_i = 500 \text{ W/m}^2\cdot\text{°C}$$

[3 marks]

**SECTION B**

- 3 (a) Explain the difference between laminar and turbulent flow. [4 marks]
- (b) Derive the basic equation of fluid statics. [8 marks]
- (c) What is the absolute pressure at the bottom of the cylindrical tank shown in Fig. 1, filled to a depth of  $H$  with crude oil, with its free surface exposed to the atmosphere, pressure 101 kPa? The specific gravity of the crude oil is 0.846. Give the answers for:
- (i)  $H = 15.0$  ft and
  - (ii)  $H = 5.0$  m (pressure in Pa).
  - (iii) What is the purpose of the surrounding dike?

[Data: 1 ft = 0.303m]



**Fig. 1**

[8 marks]

- 4 (a) What do you understand by the term distillation? Give two types of distillation [4 marks]
- (b) A distillation column is fed with a mixture of benzene and toluene, in which the mole fraction of benzene is 0.35. The column is to yield a product in which the mole fraction of benzene is 0.95, when working with a reflux ratio of 3.2, and the waste from the column is not to exceed 0.05 mole fraction of benzene. If the plate efficiency is 60 per cent, estimate the number of plates required. The relation between the mole fraction of benzene in liquid and in vapour is given in Table 1:

**Table 1**

Mole fraction of benzene in liquid ( $x$ )	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Mole fraction of benzene in vapour ( $y$ )	0.20	0.38	0.51	0.63	0.71	0.78	0.85	0.91	0.96

[15 marks]

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(c) State any one material that is used for the construction of a distillation column. [1 mark]

5 (a) Describe one method of operating evaporators. [3 marks]

(b) With the aid of diagrams, explain the terms (i) single effect and (ii) multiple effect evaporators. [8 marks]

(c) State one advantage of multiple effect evaporation compared to single effect evaporation. [1 mark]

(d) 2000 kg of a 5 per cent slurry of calcium hydroxide in water is to be prepared by diluting a 20 per cent slurry. Draw a block diagram describing this process. Perform mass balance calculations to determine the quantities required. The percentages are by weight. [8 marks]

6 (a) Discuss the following terms:

- (i) Free moisture
  - (ii) Bound moisture
  - (iii) Humidity
  - (iv) Dew point
- [8 marks]

(b) A wet solid is dried from 25 to 10 per cent moisture under constant drying conditions in 15 ks (4.17 h). If the critical and the equilibrium moisture contents are 15 and 5 per cent respectively, how long will it take to dry the solid from 30 to 8 per cent moisture under the same conditions? [6 marks]

(c) Describe any two industrial equipment used for drying. [6 marks]

***End of Question Paper!!!***

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