NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
BACHELOR OF SCIENCE HONOURS DEGREE
SUPPLEMENTARY EXAMINATIONS – AUGUST 2014
PRINCIPLES OF PROCESS ENGINEERING – SCH 2218
TIME: 3 HOURS

Instructions to candidates:

1. Answer all questions in Section A and any three questions in Section B.

2. Show all your steps clearly in any calculation

3. Start the answers for each question in a new page

Extra material

1. Graph paper

2. Conversion Factors Chart

SECTION A

1 (a)   Define the following terms:

      (i)   Chemical/Process Engineering

      (ii)   Transport phenomena

      (iii)   Unit Operations   [9]

 (b)   Explain the difference between laminar and turbulent flow   [4]

 (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 fow

     (ii) heat transfer   [6]

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

(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^2.^{o}C)

G = mass velocity (kg/s.m^2)

k = thermal conductivity (W/m.^{o}C)

c_p = specific heat (J/g.^{o}C)

D = diameter

μ = absolute viscosity (kg/m.s)   [14]

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

$k = 0.12$ W/m.^{o}C

$c_p = 4.2$ J/g.^{o}C

$D = 0.11$ m

$\mu = 0.034$ kg/m.s

$h_i = 500$ W/m^2.^{o}C   [3]

SECTION B

3 (a) Explain the difference between laminar and turbulent flow   [4]

(b) Derive the basic equation of fluid statics   [8]

(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? The specific gravity of the crude oil is 0.846. Give the answers for:

(i) H = 15.0 ft (pressure in lbf/in^2), and
(ii) H = 5.0 m (pressure in Pa and bar).
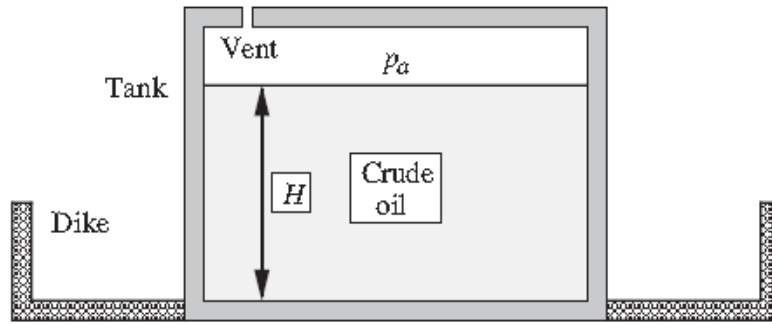(iii) What is the purpose of the surrounding dike?

Fig. 1

[8]

4 (a) What do you understand by the term distillation. Give two types of distillation   [4]

(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]

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

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

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

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

(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]

6 (a) Discuss the following terms
   (i)   Free moisture
   (ii)   Bound moisture
   (iii)   Humidity
   (iv)   Dew point   [8]

 (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]

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

END OF QUESTION PAPER!!!