

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
END OF SEMESTER 1 EXAMINATIONS – JANUARY 2004
CHEMICAL ENGINEERING PLANT DESIGN – SCH 4108
TIME – (3) THREE HOURS

INSTRUCTIONS TO CANDIDATES

Answer **FIVE** questions only. Total marks is 100.

- 1.
- (a) Identify some of the principal events leading to spillage and leakage in petroleum refineries and/or chemical plants. Provide specific examples to support the selections. (15 marks)
- (b) Approximately 25kg/s of vapor are released to the atmosphere. The lower exposure limit C_L for the vapor is 0.010m^3 vapor / m^3 air. The vapor density of the vapor is $2\text{kg}/\text{m}^3$. If the wind speed U_v is 3m/s, what is the distance d required for safe disposal of the vapor in the air as evaluated from the relation:
- $$d = (37Q/U_v C_L)^{0.552}$$
- where Q is the escape rate in m^3/s ? (5marks)
2. (a) Explain the following terms:
- (i) Capitalized engineering
(ii) Expensed engineering (3 × 2 marks)
- (b) Explain how to estimate total product cost giving few examples for each category. (12 marks)
3. (a) The annual direct production costs for a plant operating at 70% capacity are \$280 000 while the sum of the annual fixed charges, overhead costs and general expenses is \$200 000. What is the breakeven point in units of production per year if the total annual sales are \$560 000 and the product sells at \$40 per unit? What were the annual gross earnings and net profit for this plant at 100% capacity in 1998 when corporate income taxes required a 15% tax on first \$50 000 of annual gross earnings, 25% on annual gross earnings of \$50 000 to \$75 000, 34% on annual gross earnings above \$75 000 and 5% on gross earnings from \$100 000 to \$335 000? (12 marks)

- (b) A company must purchase one reactor to be used in an overall operation. Four reactors have been designed, all of which are equally capable of giving the required service. The following data apply to the four designs:

	Design 1	Design 2	Design 3	Design 4
Fixed capital investment	\$10 000	\$12 000	\$14 000	\$16 000
Sum of operating and fixed costs per year (all other costs are constant)	\$ 3 000	\$2 800	\$2 350	\$2 100

If the company demands a 15% return on any unnecessary investment, which of the four designs should be accepted?

(8 marks)

4. Put the following linear programming problem into standard form:

(a) $\max f(\mathbf{x}) = 3x_1 + 2x_2 + 5x_3 \dots\dots\dots(1)$

Subject to: $13x_1 + 14x_2 - 15x_3 \leq 40 \dots\dots\dots(2)$

$9x_1 + 18x_2 + 3x_3 \leq 25 \dots\dots\dots(3)$

$x_2 \geq 10 \dots\dots\dots(4)$

$x_j \geq 0; \quad j = 1, 2, 3$

(6 marks)

- (b) Find all basic solutions, basic feasible solutions and optimum solution of the following Linear Programming Problem.

$\min f(\mathbf{x}) = x_1 - x_2 + x_3$

subject to: $x_1 + 2x_2 + 3x_3 = 6$

$4x_1 + 5x_2 - 6x_3 = 6$

$x_j \geq 0; \quad j = 1, 2, 3,$

(14 marks)

5. (a) Define what is meant by:

(i) an open loop system

(ii) a closed loop system

(8 marks)

- (b) With the aid of a sketch diagram, explain how a feed forward control system operates.

(12 marks)

- 6 (a) The following equation shows the effect of the variables x and y on the total cost for a particular operation:

$$C_T = 2.33x + 11900/xy + 1.86y + 10$$

Determine the values of x and y, which will give the least total cost?
(12 marks)

- (b) Explain any two following:

- (i) Preliminary or quick estimate design
- (ii) Detailed estimate design
- (iii) Detailed or firm process design

(8marks)

END OF QUESTION PAPER!!!