



NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
BACHELOR OF SCIENCE HONOURS DEGREE
END OF FIRST SEMESTER EXAMINATIONS – DECEMBER 2005
CHEMICAL ENGINEERING PLANT DESIGN – SCH 4108
TIME: (3) THREE HOURS

INSTRUCTIONS TO CANDIDATES

Answer **FOUR** questions only. Total marks are 100.

1. (a) Explain with the aid of sketch diagrams what you understand of the following phrases in Plant Design:
- (i) Optimum economic design
 - (ii) Optimum operation design (16 marks)
- (b) What are the major differences between the three flow sheeting processes? (9 marks)
2. (a) The trend in the fertilizer industry during the past few years has been to go larger and larger fertilizer plants. In terms of plant location, what are the more important factors that should be considered and which factors become even more important as the size of the plant is increased? Are these factors of equal importance regardless of the type of fertilizer produced? (15 marks)
- (b) Outline and present solutions to the materials handling, waste disposal and safety problems that are encountered in the nitric acid plant. (10 marks)
3. (a) Explain fully the following terms with the aid of a sketch diagram:
- (i) Operating time
 - (ii) Rate of production
 - (iii) Break-even point (15 marks)
- (b) (i) The purchased cost of a 75 litre glass lined, jacketed reactor (without drive) was USD2 500 on January 1, 2000. Estimate the purchased cost of a similar 450 litre glass lined, jacketed reactor (without drive) on January 1, 2004. Use the Marshall and Stevens equipment-cost index (all industry) to update the purchase cost of the reactor.
- | | | |
|-----------------|------------|-----------|
| January 1, 2000 | -----237.3 | |
| January 1, 2004 | -----248.5 | (5 marks) |

- (b) (ii) If a process plant was erected in Mutare area for a fixed capital investment of USD568 000 in 1990, determine what the estimated fixed capital investment would have been in 1995 for a similar process plant located in Bulawayo with thrice the process capacity but with equal number of process units?

1990 -----214.65

1995 -----228.19

(5 marks)

4. (a) The annual direct production costs for a plant operating at 75% capacity are \$300 000 while the sum of the annual fixed charges, overhead costs and general expenses is \$225 000. What is the breakeven point in units of production per year if the total annual sales are \$600 000 and the product sells at \$45 per unit? What are the annual gross earnings and net profit for this plant at 100% capacity if the corporate income taxes require a 24% normal tax on the total gross earnings plus a 28% surtax on gross earnings above \$50 000? (12 marks)

- (b) A plant produces bags of cement at the rate of C units per day. The variable costs per bag of cement have been found to be USD $52.65 + 0.1C^{1.5}$. The total daily fixed charges are USD2 750, and all other expenses are constant at USD8 325 per day. If the selling price per bag of cement is USD273, determine:

- (i) The daily profit at a production schedule giving the minimum cost per bag of cement.
(ii) The daily profit at a production schedule giving the maximum daily profit.
(iii) The production schedule at the break-even point. (13 marks)

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

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

$$\text{subject to: } x_1 + 2x_2 + 3x_3 = 6$$

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

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

(15 marks)

- (b) With the aid of diagrams explain what is meant by:

- (i) an open loop system
(ii) a closed loop system

(10 marks)

END OF QUESTION PAPER!!!