National Exams December 2013

04-Chem-A5 – Chemical Plant Design and Economics

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.

3. Any non-communicating calculator is permitted.

4. The questions are of equal value. The candidate will answer any five of the six questions. Only the first five questions as they appear in the answer book will be marked.

5. Most questions require an answer in essay format. Clarity and organization of the answer are important. Some of the questions require calculations - please show all your steps.

Question 1 Process Design **(20 marks)**

Consider a process for making a mixture of two liquid products that involves the reaction between a gas and a liquid in the presence of a catalyst in solid forms (metal oxide). The reaction is done in a well-mixed reactor at high temperature and pressure. The products of reaction leave the reactor as a vapour that is condensed to give a liquid mixture containing two products.

(i) Describe in a clear and concise manner a process to separate the two products in the liquid mixture.

4

(ii) Prepare a qualitative flow sheet for the process, including the separation step described earlier. Show all pieces of equipment that would be needed.

8

(iii) List each piece of equipment and indicate in a table format, the information needed in order to design the equipment.

8

Question 2 Cost estimation **(20 marks)**

A medium size plant that produces chemicals for the petroleum industry has a total capital investment of $5 million and a working capital of $750,000. This plant has a production capacity of 32 metric tonnes per day and operates all year long except for two planned maintenance shutdowns of 10 days each.

(i) Explain briefly and concisely what are the meanings of the working capital and turnover ratio in cost accounting.

6

(ii) What is the annual production capacity of this plant?

2

(iii) Determine the unit selling price of the product if the turnover ratio in the plant was 0.8.

12

Question 3 Project Risk Assessment **(20 marks)**

When evaluating the feasibility of a plant design project, there are several potential risks factors.

(i) List 4 potential risk factors and what you would do to mitigate their impacts.

12

(ii) How would you prove and ensure that these risks are eliminated?

8

Question 4 Interest and investment costs (20 marks)

If the original loan of $18,000 to purchase an air compressor was made at 3.9% simple interest for 3 years. However, if at the end of the 3 years, no amount of the loan and no interest were paid and the plant negotiated to get the loan extended for 3 more years at a new effective compound-interest rate of 5.2% per year.

(i) Explain in a concise manner the difference between the nominal interest rate and the effective interest rate.

4

(ii) Determine the amount owed by the plant at the end of the first 3 years.

6

(iii) Calculate the total amount owed by the plant at the end of the total loan period.

10

Question 5 Depreciation (20 marks)

There are several methods for determining depreciation.

(i) List and explain in a concise manner three methods for determining depreciations. What are the advantages and disadvantages of each of them?

6

(ii) If the original cost of an evaporator is $320,000 and the useful life of the evaporator is 12 years. The scrap value of this equipment is $20,000 and the effective annual interest rate for the depreciation fund is 8%. Calculate the asset value of this evaporator at the end of the tenth year. Make it clear any assumptions you have made.

14

Question 6 Health & Safety and Environmental Issues (20 marks)

In industrial plants, there are several safety "risk hot spots"; those are items, equipment or process areas that are more prone to disasters.

(i) List five of these safety risk hot spots in large chemical plant and explain in a concise manner why they are such.

10

(ii) Explain the steps you would use to minimize their potential risks and what tools you would use.

10