National Exams May 2014

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 a CLOSED BOOK EXAM.

3. Any non-communicating calculator is permitted.

4. FIVE (5) questions constitute a complete exam paper. The questions are of equal value. The candidate may answer any five of the six questions. Only the first five questions as they appear in the answer book(s) 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)

Prepare in the form of a flow sheet, an outline showing the sequence of steps in the complete development of plant for producing pure ammonia (NH_3) from air and liquid water as feedstock.

Let's assume the following simple catalytic chemical reaction for the synthesis of ammonia:

$$N_2 + 3H_2 \rightarrow 2\,NH_3$$

A detailed analysis of the points to be considered at each step should be included and the outline should take the project from the initial conceptual idea to the stage where the plant is fully operational.

Boiling Points of the following Gaseous Compounds at 1 atm[1]:
- NH_3:   -33°C
- H_2:   -253°C
- N_2:   -196°C
- O_2:   -183°C

[1] Data extracted from T.M. Duncan and J.A. Reimer (Chemical Engineering Design and Analysis: An Introduction; Ambridge University Press, 1998.

Question 2 Cost Estimation   (20 marks)

Calculate what would be the purchase cost in 2014 of a shell and tube heat exchanger that has a heating surface of 800 ft^2.

We know that similar heat exchangers with one quarter the heating surface would cost $4000 in 2014. We are also told that the purchase cost capacity exponent for this type of heat exchangers is 0.60 for surface area ranging from 100 to 400 ft^2 and 0.81 for surface area ranging from 400 to 2000 ft^2.

Question 3 Depreciation   (20 marks)

i.   A pump purchased for $30,000 has a useful life of 15 years and a scrap value of $4000. If the annual interest rate for the depreciation fund is 6%, calculate the asset value of this pump at the end of the 10th year. Make it clear any assumptions that you have made.

ii. There are several methods for determining the amount of capital depreciation. Explain in a concise manner two of these methods and list a few of the advantages and disadvantages for each of them.

Question 4   Interest and Investment Costs   (20 marks)

An original loan of $21,000 was taken to purchase a glycol cooler at a monthly interest rate of 2.4%.

   i.   Calculate the total amount of the principal plus simple interest due after 3 years if no intermediate payments were made.

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   ii.   Calculate the total amount of principal plus compounded interest due after 3 years if no intermediate payments were made.

5

   iii. Estimate the nominal and effective interest rates when the interest is compounded monthly.

10

Question 5   Project Risk Assessment   (20 marks)

   i.   Explain in a concise manner the factors that affect the profitability of a major investment such as the construction and launching of a manufacturing firm.

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   ii.   When evaluating the feasibility of a plant design project, there are several potential risk factors. List 5 potential risk factors and what you would do to mitigate their impacts.

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Question 6   Health and safety and Environmental Issues   (20 marks)

   i.   In industrial plants, there are several safety risk areas. List five of these risk areas in large chemical plants and, explain in a concise manner why they are such and how you would mitigate their potential impacts?

   ii.   There are several design optimization methods. Explain briefly and concisely the difference between optimum economic design and optimum operation design.