NATIONAL EXAMINATIONS DECEMBER 2019

16-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. The examination is a **CLOSED BOOK EXAM.** One aid sheet allowed written on both sides.
3. Candidates may use approved **Sharp/Casio** calculator.
4. **Five (5) questions** constitute a complete exam paper.
5. The questions are of equal value (**20 points each**).
6. Only the **first five questions** as they appear in the answer book(s) will be marked.
7. Clarity and organization of the answer are important. For questions that require calculations, please show all your steps.
8. State all assumptions clearly.

Q1. Scaleup of reactors in a chemical process involves two, somewhat interdependent aspects; selection of the type of reactor to be used and the actual design of the selected type of reactor. List and describe the uncertainties and problem areas involved in the scaleup of homogeneous reaction systems and heterogeneous reaction systems.

Q2. Diagrams are used extensively by all disciplines of engineers to convey ideas and data. The process flow diagram is usually the first drawing that will be produced by the process engineer for an engineering or development project. List and describe the ten essential elements of a typical chemical engineering process flow diagram.

Q3. A firm is evaluating two competing projects. The first is a new inorganic chemicals plant, while the second is the expansion of a textile fibers facility. The process engineers have estimated the projected annual revenue, total capital investment, and total annual cost (without capital recovery) for each project as follows:

	Cost of Inorganic Chemicals Plant	**Cost of Textile Fibers Plant Expansion**
Projected Revenue	$33,700,000	$30,900,000
Total Capital Investment	$52,500,000	$57,300,000
Total Annual Cost	$25,100,000	$21,500,000

Both the new and expanded plants would have an estimated life of 20 years. The firm's marginal acceptable rate of return is 12.5% before tax, and its marginal federal and provincial income tax rate is 52%. Assuming straight-line depreciation with zero salvage and that 100% of the investment is depreciable, determine which project the firm should fund using internal rate of return method.

Q4. A cement plant ball mill emits particulate matter that must be controlled to meet provincial air pollution regulations. Three particulate matter control devices being evaluated, each of which can control these emissions to the same level, are as follows:

(1) A high-energy wet scrubber
(2) An electrostatic precipitator (ESP)
(3) A fabric filter

Unlike the wet scrubber, the ESP and the fabric filter each recover salable cement dust, and, accordingly, revenue can be attributed to these two options. The economic specifications for the three devices are as follows:

Parameter	Wet Scrubber	ESP	Fabric Filter
Life (years)	10	20	15
Marginal Tax Rate	0.52	0.52	0.52
Revenue (in $)	0	290,000	290,000
Total Capital Investment	5,300,000	9,750,000	7,870,000
Total Annual Cost	2,770,000	1,840,000	2,345,000
Salvage Value	0	0	0
Depreciation (straight line)	530,000	487,500	524,667

Two scenarios are presented; one with an after-tax hurdle rate of 6% and the other with an after-tax hurdle rate of 18%. For each of the two scenarios, determine the most economical particulate matter control device to control dust from the ball mill using equivalent uniform annual revenue (EUAR) analysis.

Q5. All chemical plants require support systems to service the processes contained in the plant. The most common support systems are utility systems and offsite systems. Among the major units found in the offsites of most plants are storage facilities, road and rail loading facilities, waste disposal facilities and effluent water-treating facilities. List and describe the various categories of plant storage facilities including the types of chemicals stored.

Q6. Among the principal functions of a chemical process engineer is to generate ideas for the enhancement of the company's production business. In carrying out this function the engineer is required to study various processing routes or changes to existing process routes and configurations. When satisfied that the technical aspect of any proposed changes or additions is feasible and sound, the process engineer must now satisfy the company management that it is economically attractive. The proposal must also be shown to be the best of any possible alternatives that have been studied to achieve the same objective.

Process studies are usually initiated after a very precise definition by the company's management for immediate and long-term production objectives. Often such a definition results in changes being required to be made to the process facilities in either the short term or long term to meet these objectives. The company will look to the process engineers to provide definition of these changes and to support the definition(s) with whatever technical and economic data necessary for management to make their "go/no go" decisions. List and describe 10 important steps in a typical process study for expansion of an existing process configuration by adding a new group of chemical plants.