

December 2002 National Exams

98-Chem-A5, Chemical Plant Design & 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 the assumptions made.
2. Any non-communicating calculator is allowed. This is an OPEN BOOK exam.
3. The questions are of equal value. The candidate will answer any five of the seven questions. Only five questions that you answer will be marked.
4. Most questions require an answer in essay format. Clarity and organization of the answer are important

1) Cost Estimation (20 marks)

The attached process flow sheet is for a HYDEAL unit (Conversion of toluene into benzene). Prepare a table illustrating how an equipment factored estimated would be prepared for this unit. What is the expected accuracy of this type of estimate and at what points during a project would it normally be prepared?

2) Process Selection and Design (20 marks)

You are faced with having to recommend which process would be suitable for the production of ethyl benzene from ethylene and benzene. One process is the liquid phase alkylation of benzene with ethylene using Aluminium Chloride as a catalyst. This catalyst must be promoted with Hydrochloric acid. There is a significant by product of Aluminium Hydroxide. The process is well established and generally somewhat less expensive to build and operate than the competing process. The competing process is relatively new, in fact it has only been demonstrated on a pilot scale. It involves the vapour phase alkylation of benzene with ethylene over a fixed catalyst in a novel catalytic distillation reactor. This is a lower conversion per pass system that would require quite a large recycle of ethylene at high pressure. Prepare an assessment of the two projects by giving the pros and cons of both.

3) Health Safety and Environmental Issues (20 marks)

The practice of engineering has been changing dramatically for some time now. This is particularly the case for process design. It is not that long ago that a process engineer would have the responsibility for a completely technical aspect of a design. Discuss how Health Safety and Environmental issues have changed this. Discuss how these issues impact the Process Design Engineer as compared to an "Engineering Scientist" ?

4) Profitability Evaluation (20 marks)

In today's economy with forces of globalization and technological change, it is expected that the overall economy will continue to be quite volatile. The generation of the

timing and size of cash flows is a relatively straightforward process of simple accounting. In an orderly market and economy it has generally been assumed that cash flows are deterministic. In fact the data concerning cash flows have always been an estimate and subject to uncertainty. In view of the anticipated continuing volatility in the market, there are several advanced techniques that are better able to reflect these uncertainties than the deterministic approach. Describe at least two of these procedures.

5) **The Design Process (20 Marks)**

The Design process is a general procedure that impacts most of human endeavor. Engineering design is a subset of this. The Engineering Design process is considered to involve "Synthesis, Analysis and Optimization". Given the following scenario how would this be applied.

Your research people have investigated a conversion process that would appear to be an attractive route to a potentially high value added product. You have the results of several bench scale runs. Your responsibility is to design a "reaction Section" for a commercial plant to produce this product.

6) **The role of Optimization in Design and Operation of Chemical Processes (20 Marks)**

Optimization of a process design is often related to equipment, for example economic pipe diameter, optimization of the flow of cooling water to a heat exchanger, or the selection of an optimum reflux ratio. A further very important optimization design issue is related to selection of the appropriate equipment to meet basic operating specifications while simultaneously giving maximum profit or minimum cost. A typical example is a manufacturer who has to blend various materials to produce several final mixes, and meet a tight delivery schedule. What tools are available to tackle this problem. Give a description as to how these tools might be used.

7) Mass and Heat Transfer (20 Marks)

In the design of almost any mass-transfer device, and many heat exchangers, phase relationships are vital. There have been many methods developed for the prediction of vapour liquid and vapour liquid/liquid . These methods fall into three general classes.

For the three following methods give the general category that they would fall into and give an indication as to where these methods would be applied.

- 1) Grayson Streed**
- 2) Peng-Robinson**
- 3) NRTL**

TK-101	P-101 A/B	E-101	H-101	R-101	C-101 A/B	E-102	V-101	V-103	E-103	E-106	T-101	E-104	V-102	P-102 A/B	E-105
Toluene Storage Tank	Toluene Pump	Feed Preheat.	Feed Heater	Reactor	Recycle Gas Compressor	Reactor Effluent Cooler	H.P. Phase Separator	L.P. Phase Separator	Tower Feed Heater	Benz. Reboiler	Benz. Tower	Benz. Condens.	Reflux Drum	Reflux Pumps	Product Cooler

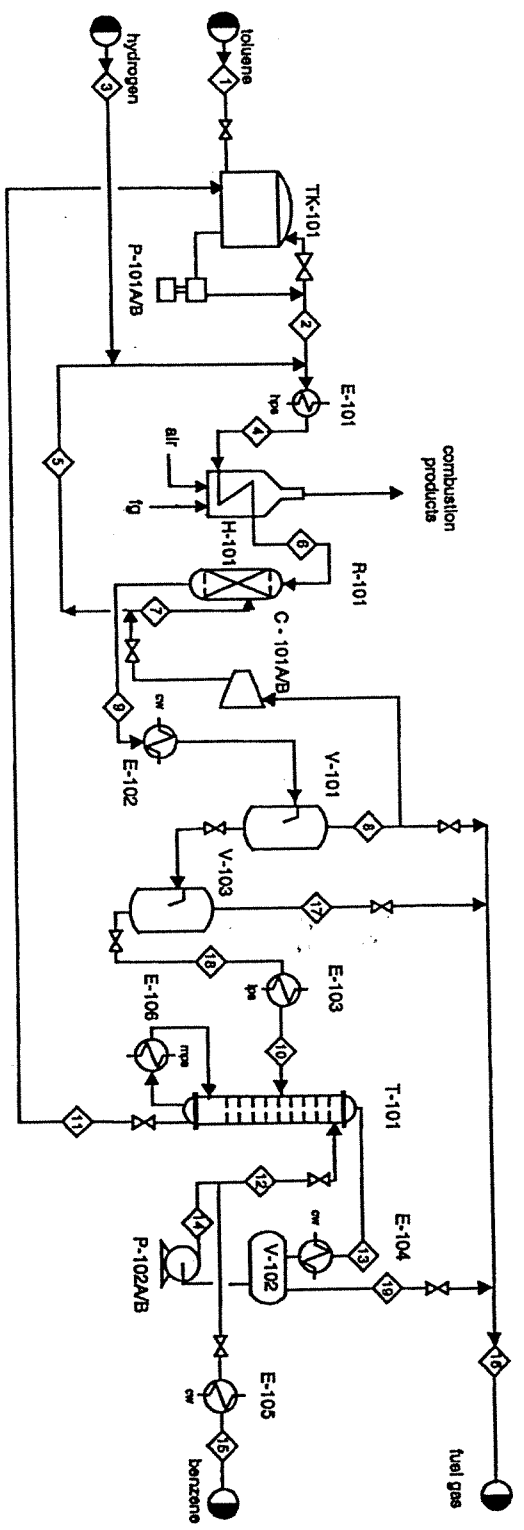


Figure 1.3 Skeleton Process Flow Diagram (PFD) for the production of benzene via the hydrodealkylation of toluene.