

December 2009 National Exams

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 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) **Flowsheet Synthesis and Development (20 marks)**

In the usual design process there are several types of flow sheets that are developed from the initial preliminary assessment of a project to the construction and start-up phase. Describe at least three different flowsheets and their purpose keeping mind that we are dealing with process engineers.

2) **Software Use in Process Design (20 marks)**

Computers and sophisticated software have become an increasingly vital aspect not only of design, but operation, and financial assessment . There are several issues today that make it imperative that any design be as efficient as possible and meet increasingly stringent environmental constraints. The current economic slump combined with the rapid growth of offshore competition makes this issue imperative. Discuss how sophisticated software can assist in this design process. For example can you explain why it usually requires a computer to effectively design a thermosyphon reboiler.

3. **Health & Safety. Loss prevention and Environmental Issues (20 marks)**

In today's environment the process designer must take the issues of Health and Safety, Loss prevention and Environmental stewardship into consideration. The current furor over the alleged danger of Bisphenol A (BPA) is a perfect example of media hysteria over what many believe to be a non-issue. As a process engineer in a petrochemical company how do you believe that your employer should deal with these issues and how would you be impacted personally? The BPA issue is simply for illustration, if the candidate wishes to discuss other significant situations this is acceptable.

4. Feasibility Assessment (20 Marks) (See Appendix A)

The figure in the appendix is a flow diagram for an Acid Gas Removal system. The following is a recent statement of the U.S. Department of Energy.

Existing capture technologies, however, are not cost-effective when considered in the context of sequestering CO₂ from power plants. Most power plants and other large point sources use air-fired combustors, a process that exhausts CO₂ diluted with nitrogen. Flue gas from coal-fired power plants contains 10-12 percent CO₂ by volume, while flue gas from natural gas combined cycle plants contains only 3-6 percent CO₂. For effective carbon sequestration, the CO₂ in these exhaust gases must be separated and concentrated.

CO₂ is currently recovered from combustion exhaust by using amine absorbers and cryogenic coolers. The cost of CO₂ capture using current technology, however, is on the order of \$150 per ton of carbon - much too high for carbon emissions reduction applications. Analysis performed by SFA Pacific, Inc. indicates that adding existing technologies for CO₂ capture to an electricity generation process could increase the cost of electricity by 2.5 cents to 4 cents/kWh depending on the type of process.

Furthermore, carbon dioxide capture is generally estimated to represent three-fourths of the total cost of a carbon capture, storage, transport, and sequestration system.

With reference to the drawing and considering the fact that flue gas temperatures and flow are in the order of 150 deg C. and 100 feet/second at the top of a typical power plant stack. Can you give a designers perspective as to why the costs should be so high and what you might consider as a potential to reduce this cost.

5. Project Profitability (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. It is not reasonable to assume that cash flows will be deterministic. Two more sophisticated approaches are scenario analysis and stochastic evaluation. Describe these procedures, giving the advantages and disadvantages of each. Can one predict the future?

6. Chemical Reactor Design (20 Marks)

The process engineer has to make a selection of an appropriate reactor design for liquid, vapour and mixed phase reactors. Restricting the discussion to liquid phase there are basically three types of reactors commonly used, Batch, CSTR and Plug Flow. Describe the features of each and what are the usual considerations as to why you would select one over the others. There are other liquid phase reactors other than the above three, can you think of other options?

7 Selection of suitable separation processes (20 Marks)

As a process designer you have a complex mixture to fractionate. The column requires thirty actual stages. The desired product is the bottoms product however it is heat sensitive. There are several ways to deal with this situation, describe these and give the reasons why they are effective.

Acid Gas Removal System



- Componenets Labelled**
1. Absorber Tower
 2. Flash Vessel
 3. Acid Gas Cooler
 4. Knockout Drum
 5. Pump
 6. Sweet-Gas / Lean Desolvent
 7. Stripped Solvent
 8. Flash Drum
 9. Lean Solvent
 10. Lean Solvent

- Fluide Legend**
- Process Gas
 - Solvent - Lean
 - Solvent - Saturated
 - Stripper Water
 - Subsided Solvent
 - Acid Gas

