

May 2008 National Exams

Chem A5 Chemical Plant Design and Economics

3 Hours Duration

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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) **Configuration of Chemical Processes (20 marks)**

Most Chemical Processes involve three general stages Reaction Separation and Finishing In general terms how one would compare a process for the manufacture of a pharmaceutical to a process for the manufacture of a chemical solvent Of particular interest are the various comparable unit operations involved

2) **Process Safety and Management (20 marks)**

**Flixborough**

The Flixborough Works of Nypro Limited was designed to produce 70 000 tons per year of caprolactam a raw material for the production of nylon The process used cyclohexane as a raw material and oxidized it to cyclohexanol in the presence of air within a series of six catalytic reactors Under process conditions cyclohexane vaporizes immediately upon depressurization forming a cloud of flammable cyclohexane vapor mixed with air Reactor 5 was found to have a small crack in the stainless steel structure and was removed The number 4 reactor was connected to the last reactor in the series using a 20 pipe even though the reactors are normally connected using 28 pipe The temporary section of piping was not properly supported and it ruptured upon pressurization releasing an estimated 30 tons of cyclohexane in a large cloud An unknown ignition source caused the cloud to explode leveling the entire plant facility A total of 28 people died another 36 were injured and damage extended to nearby homes shops and factories The resulting fire in the plant burned for over 10 days

**Bhopal**

Bhopal is located in a central state of India and on December 3 1984 an accidental release of methyl isocyanate (MIC) occurred killing 2 000 nearby residents and injuring over 20 000 The plant which was partially owned by Union Carbide and partially owned by local investors manufactured pesticides One of the intermediates was MIC MIC is a liquid at ambient conditions it boils at 39.1 °C its vapor is heavier than air and it is very toxic even at low concentrations The maximum allowable exposure concentration of MIC for workers during an eight hour period is only 0.02 parts per million (ppm) Death at large dose is due to respiratory damage MIC reacts with water exothermically but slowly and the heat released can cause MIC to boil if cooling is not provided On the day of the accident the unit using MIC was not operating due to a labor dispute The storage tank holding the MIC was contaminated with water from an unknown source A reaction between MIC and water occurred in the tank causing the temperature to rise above the boiling point of MIC The vapors generated escaped the pressure relief valve on the tank and were diverted into a scrubber and flare system designed to control MIC releases Unfortunately the release control system was not operating on this day and an estimated 25 tons of MIC vapor was released into the surrounding community with catastrophic effects

These two incidents were to a large degree responsible for the greatly increased concern on the part of the general public about the safety of the chemical industry There are several issues common to both incidents that are examples of failure in the design and operation procedures for both units Discuss these

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

Your company has a process that produces a significant amount of byproduct which can only be valued as fuel. This material however has a potentially reactive group and there is a possibility of upgrading the material to a higher value material. Describe how you would approach the problem to the point where you could approach your management with sufficient information so that a decision could be made to proceed to a scope design or not.

**4) Profitability Evaluation (20 marks)**

Should the preliminary assessment of the potential process for upgrading the byproduct look promising, how would one proceed with a scope design and profitability evaluation?

**5) The role of Software in Design and Operation of Chemical Processes (20 Marks)**

In today's chemical engineering practice, software is an essential for most design and operation of chemical plants. Describe where one would use software in the design and operation of a unit and give a general description of the particular software employed. Are there potential problems with the use of software?

**6) Heat systems (20 Marks)**

In today's world, there is a real concern about energy conservation, and rightly so. Many large chemical processes and in particular oil refineries are large consumers of energy and as a result, significant emitters of Carbon Dioxide. How would one approach the improvement of energy consumption in such a situation?

**7) Phase Equilibria and Transfer Properties (20 Marks)**

Any process design requires good Physical and Thermodynamic properties. This is particularly important when one is dealing with separation of phases. What are some of the sources for this data?