Semester II 2013/2014

Exam Code(s) 3BS, 3BPC
Exam(s) 3rd Science

Module Code(s) CH335
Module(s) Industrial Chemistry

External Examiner(s) Professor D. Wass
Internal Examiner(s) Professor P.V. Murphy
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INSTRUCTIONS: Answer Four questions: one question must be attempted from each section (A, B and C)
Separate Answer Books are not required for each section.
All questions carry 25 Marks distributed as shown.
Leave the front page of the Answer Book blank and clearly list on it the numbers of the questions attempted.

Duration 2hrs
No. of Pages 5 (including this front page)
Department(s) Chemistry

Requirements None
Section A

1. Answer each of the following:

   a) Industrial chemicals are often classified by the commercial sector for which they are produced. Name the main 5 industrial sub-sectors in which industrial chemicals are used and give two examples of applications for each of the five sectors. [5 marks]

   b) Refinery processes are used to refine chemicals and produce consumer products. List and explain three typical refinery processes and include examples. [5 marks]

   c) Define the term syngas and explain three of its main uses in industry. Include details of chemical reaction, conditions of temperature and pressure and catalysts used where appropriate. [15 marks]

2. Answer each of the following:

   a) Describe the structure of the chemical industry using a tree diagram. Name the groups using the terms: intermediates, consumer products, raw materials and base chemicals and give an approximate number of chemicals in each group. Give 5 examples of typical chemicals for each group.

   Group | Examples
   -------|---------
   
   [10 marks]

   b) The Frasch and Clauss processes are processes used to extract sulphur from different sources. Describe each process in detail and include detailed chemical reactions where appropriate. [15 marks]
Section B

3. Answer each of the following:

   a) List and explain *four* cost-based factors that would have to be considered when choosing an industrial process. Base your answer on a typical batch process.  
      [8 marks]

   b) Describe, in detail, the Monsanto acetic acid process. Include a schematic that includes and describes the chemical steps involved.  
      [17 marks]

4. Answer each of the following:

Ziegler and Ziegler-Natta catalysts were developed to produce oligomers and polymers on an industrial scale.

   a) Describe, in detail, *two* chemical reactions that use Ziegler and Ziegler-Natta catalysts. In your description, provide chemical structures and reaction mechanisms where appropriate.  
      [10 marks]

   b) Discuss Ziegler and Ziegler-Natta catalysts in terms of their industrial importance and their role in stereochemical synthesis.  
      [15 marks]
Section C

5. **Answer each of the following:**

   a) Identify the functional groups associated with thermally hazardous decomposition potential in the following list:  

   - R − CH₂ − CH₂ − CH₃
   - RCH = CHR
   - R − C ≡ C − R
   - R − CH₂ − OH
   - R − NH₂
   - R − NO₂
   - R − O − O − R
   - R − C₆H₅

   **[4 marks]**

   b) Identify the two chemicals which have most frequently been the cause of hazardous decomposition incidents in the chemical industry and discuss the underlying reasons.  

   **[6 marks]**

   c) Hydrogen peroxide undergoes the following exothermic decomposition reaction. Note that phase subscript labels have been intentionally omitted.

   \[
   \text{H}_2\text{O}_2 \rightarrow \text{H}_2\text{O} + \frac{1}{2} \text{O}_2 \quad \Delta H = -98 \text{ kJ/mol} \text{H}_2\text{O}_2
   \]

   Give two reasons why this reaction is inherently hazardous.  

   **[5 marks]**

   d) State Hess’s Law and use it to estimate the heat of reaction for the methanolysis of acetic anhydride given the following data.

<table>
<thead>
<tr>
<th>Species</th>
<th>ΔH°, kcal/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic Anhydride (l)</td>
<td>-149.2</td>
</tr>
<tr>
<td>Methanol (l)</td>
<td>-57.1</td>
</tr>
<tr>
<td>Acetic acid (l)</td>
<td>-115.8</td>
</tr>
<tr>
<td>Methyl Acetate (l)</td>
<td>106.5</td>
</tr>
</tbody>
</table>

   State the reasons why this reaction is of importance in the field of adiabatic Calorimetry. Illustrate your answer with a sketch of the expected pressure and temperature versus time relationship for the reaction.  

   **[10 marks]**
6. Answer each of the following:

a) The first step of an industrial technical project is the execution of a feasibility study.

(i) List three reasons to conduct a feasibility study. [5 marks]

(ii) List, and briefly describe, the documents generated as part of an industrial feasibility study. [8 marks]

b) Fracking, or hydraulic fracturing, is a process stimulating procedure used in the oil and gas industry to access and explore shale gas.

(i) Describe, using a diagram, the method of hydraulic fracturing. [6 marks]

(ii) Discuss the advantages and disadvantages of hydraulic fracturing. [6 marks]