**Autumn 2013 / 2014**

Exam Code(s) 3rd Science
Exam(s) CH335
Module Code(s) CH335
Module(s) Industrial Chemistry

External Examiner(s) Professor Duncan Wass
Internal Examiner(s) Professor P.V. Murphy
*Dr. J. Würmel

**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** 4 (including this front page)
**Department(s)** Chemistry

**Requirements** None
Section A

1. Answer each of the following:

a) The organic chemical industry was small-scale in the early 20th century. Give three reasons why this changed soon after.  
   [6 marks]

b) The Frasch process is a process that was used to extract sulphur from different sources. Describe each process in detail and include detailed chemical reactions where appropriate.  
   [8 marks]

c) Define the term syngas. Explain three methods used to produce syngas. Include details of chemical reactions, conditions of temperature and pressure and catalysts used where appropriate.  
   [11 marks]

2. Answer each of the following:

a) Syngas is used in a large scale industrial process to make ammonia. The process is based on the Haber process and is carried out in seven vessels. Explain the processes taking place in each vessel in detail, including details of chemical reactions for each vessel.  
   [13 marks]

b) Syngas is used to make Fischer Tropsch diesel. Explain the process and political significance of this process.  
   [6 marks]

c) Moving a chemical process from laboratory to industrial scale requires a number of important considerations. Name and explain the six steps involved.  
   [6 marks]
Section B

3. Answer each of the following:

a) In the hydration reaction of ethene to ethanol 4 moles of ethene and 6 moles of steam are fed into a reactor. The reactor effluent contains 0.155 moles of ethanol, 5.566 moles of water and 3.777 moles of ethene. Calculate the conversion and efficiency of the process. [5 marks]

b) One chemical processes that is used to add oxygen into organics is the Wacker process. Explain the Wacker process and include a schematic that describes the chemical processes involved. [6 marks]

c) Describe, in detail, the Monsanto acetic acid process. Include a schematic that includes and describes the chemical steps involved. [14 marks]

4. Answer each of the following:

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

a) Define the terms metallocene, isotactic, syndiotactic and atactic. [8 marks]

b) Draw the structure of a metallocene catalysts that will give each of the following polymers:

   (i) isotactic polymer
   (ii) syndiotactic polymer
   (iii) atactic polymer

   [12 marks]

c) Ethene is used as a monomer in addition polymer reactions. Free radical and Ziegler catalysis polymerisation using the same monomer will yield different kinds of products. Name the expected products and explain why there is a difference in the product formed. [5 marks]
Section C

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

Write an essay on the topic ‘water purification’. In your essay include details on

(i) industrial uses of purified water,
(ii) sources of water,
(iii) types of water treatment,
(iv) water contaminants, and
(v) any additional topics of your choice.

[25 marks]

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

a) Name the three main risks in executing a technical project:

[6 marks]

b) List, and briefly describe, the documents generated as part of an industrial feasibility study.

[9 marks]

c) Critically discuss the following statement:

“With wind energy technology becoming cheaper and cheaper, fracking is a waste of resources that should be spent on renewables.”

[10 marks]