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<th>Exam Code(s)</th>
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<td>Exam(s)</td>
<td>Third Science Examination</td>
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<td>CH327</td>
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<td>Module(s)</td>
<td>Validation and Industrial Chemistry</td>
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<td>Paper No.</td>
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<tr>
<td>External Examiner(s)</td>
<td>Professor K. Molloy</td>
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<tr>
<td>Internal Examiner(s)</td>
<td>Dr. L. F. Jones</td>
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<td>Mr R. McCarthy</td>
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<td>Dr W. Carroll</td>
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<td>Dr A. G. Ryder</td>
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<td>Dr J. Wurmel</td>
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**Instructions:**

Answer 2 questions from each section (*4 questions in total*)

Use separate books for each section

All questions will be marked equally

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<th>Duration</th>
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<td>No. of Pages</td>
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<tr>
<td>Department(s)</td>
<td>Chemistry</td>
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<td>Course Co-ordinator(s)</td>
<td>Dr. L. F. Jones</td>
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Section A

1. Environmental concerns have been the main driving force in the development of new cells for use in the chlor-alkali industry (production of NaOH and Cl₂). Describe these developments, giving details of the electrodes and cells used and the experimental conditions under which they operate.

   [25 marks]

2. Answer all parts.

   (i) What is syn-gas and how is it obtained?
   
   [5 marks]

   (ii) Describe the large scale catalytic production of ammonia from elemental nitrogen and hydrogen gas.

   [10 marks]

   (iii) Describe the Ziegler process for the polymerisation of alkenes and compare the conditions of the process with those of the free radical process for alkene polymerisation.

   What are the advantages offered by the recently developed metallocene catalysts?

   [10 marks]

3. Answer all parts.

   (i) What are the top two countries for chemical exports in Europe?

   [2 marks]

   (ii) Give examples of two uses which can push chemicals to the top of the chemical production list.

   [4 marks]

   (iii) Define the terms capital cost, conversion and selectivity.

   [6 marks]

   (iv) What are the most important differences between laboratory based procedures and the procedures used in industry?

   [8 marks]

   (v) Which of the following are in the top five chemicals list for inorganic chemicals and organic chemicals respectively?

   Inorganic: Cl₂, NaOH, H₂SO₄, HCl, NH₃.
   Organic: Analine, Urea, Styrene, Ethylenedichloride, asprin.

   [5 marks]
Section B

4. Answer all parts

(i) Draw a schematic diagram that shows the five main stages in mass spectrometry. Explain in detail the function of each stage. Provide the name and a description of one type of apparatus used in each stage. In your explanation follow the species under examination from injection to detection.

[10 marks]

(ii) The molecular structure of three molecules (A, B and C) is shown below. Give the m/z value of one major peak which could appear in the mass spectrum of molecule A, but not in the spectra of molecules B or C.

[10 marks]

(iii) The atomic masses of some elements are shown below:

- Hydrogen  1.0078
- Carbon    12.0000
- Nitrogen  14.0031
- Oxygen    15.9949

Using the data above, explain why nitrogen monoxide (NO) and ethane (C₂H₆) can be distinguished using high resolution mass spectrometry. Calculate the resolution factor that would be required.

[5 marks]
5. Answer all parts

(i) Explain the purpose and fundamental theory of chromatography using thin layer chromatography as an example. In your answer use and define the following terms: adsorption chromatography, partition chromatography, mobile phase, stationary phase, retention time, polarity, affinity, temperature programming and band spreading.

[10 marks]

(ii) Explain what is meant by the term ‘theoretical plates’. State and explain the mathematical formula that relates the number of theoretical plates to retention time. Outline how performance is related to the number of theoretical plates. List the factors that will affect performance in chromatography.

[10 marks]

(iii) State what stationary and mobile phases are typically used in Gas Chromatography (GC). Comment on the ability to change the mobile phase in GC in any meaningful way.

[5 marks]

6. Answer all parts

The details of a HPLC analysis of a number of analgesics are provided below.

(i) Provide a schematic diagram of the HPLC system that would be required to carry out the analysis below.

[5 marks]
(ii) Identify if the column used in this analysis is normal phase or reverse phase and justify your choice. Explain how, by knowing the type of column used, you can predict which of the three analytes is most polar. List all three analytes in order of polarity starting with the least polar one.

[5 marks]

(iii) What type of detector is used in the analysis? Draw a simple diagram showing how this type of detector works.

[5 marks]

(iv) Explain the difference between the detector used here and a diode array detector. Provide a diagram of the latter and outline its main advantage.

[5 marks]

(v) The stationary phase used in the analysis above is C18. Explain what that means providing a diagram and list two other types of stationary phases that can be used in this type of chromatography.

[5 marks]

7. Answer all parts

(i) Describe, with the aid of a diagram how an X-ray tube source works?

[7 marks]

(ii) Outline the construction and mode of operation of a wavelength dispersive X-Ray Fluorescence spectrometer.

[12 marks]

(iii) Describe (using appropriate diagrams) what is meant by intensity enhancement in XRF spectroscopy. What effect does it have on quantitative analysis?

[6 marks]