An Roinn Oideachais
agus Eolaíochta

CHEMISTRY

Leaving Certificate

Ordinary Level and Higher Level

GUIDELINES FOR TEACHERS

THESE GUIDELINES

The Chemistry Syllabus

- *emphasis* • *structure and format*
- *content* • *teaching approach*
- *resources* • *timetabling* • *changes*

Social and Applied Aspects

- *references* • *magazines and journals* • *books* • *the internet*

Instrumentation

Industrial Chemistry

- *individual visits*
- *visiting a chemical plant*

Assessment

Practical Work and Safety

- *practical work*
- *laboratory organisation and maintenance*
- *chemicals and equipment*
- *safety* • *references*

PLUS

helpful hints,
real samples,
lots, lots more...

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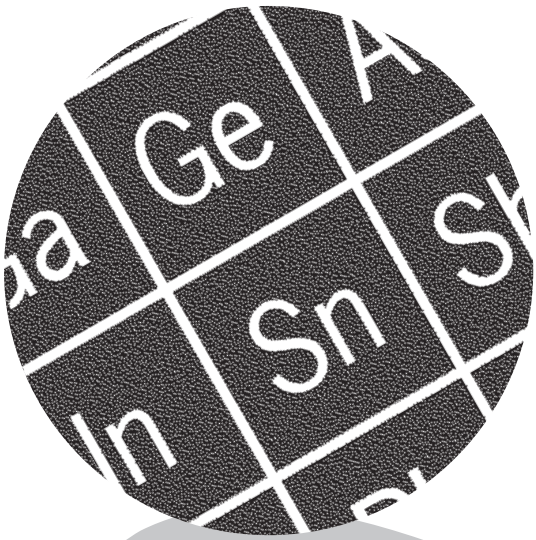
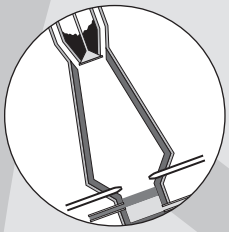
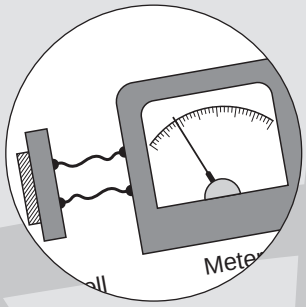
Section one
information about the syllabus







1.1 INTRODUCTION

The previous Leaving Certificate Chemistry syllabus was introduced in schools in 1983 and first examined in 1985. The syllabus has now been revised in accordance with the recommendations of the NCCA's Senior Cycle Science Steering Committee (1990). The revision takes into account

- the changes to Junior Certificate Science
- the need to emphasise the vocational value of chemistry
- the fall in uptake of the subject over a number of years (particularly at Ordinary level)
- the perceived need to shorten the syllabus.

Before the revision work began, submissions were sought from interested organisations and institutions. After the penultimate draft was completed, further consultation took place. Within the revised syllabus there are changes in emphasis, in structure and format, and in content.

1.2 EMPHASIS

The revised chemistry syllabus is practically and experimentally based. This is emphasised by the specification for the first time of mandatory experiments. The revised syllabus has the following components:

- pure chemistry, 70%
- applications of chemistry, 22.5%
- chemistry for citizens, 7.5%

This new emphasis provides a context within which students can gain an understanding of chemical laws and theories. The inclusion of the applications of chemistry will emphasise the vocational aspects of the subject and will enable students to see where it applies in the world of work. Exemplars relevant to their own lives are included wherever possible.

1.3 SYLLABUS STRUCTURE AND FORMAT

The Ordinary level syllabus and the Higher level syllabus are presented separately in the syllabus document. The Ordinary level syllabus consists of a core and four options. Only two of these options are examinable in any given year, and Ordinary level students must study one of these. Depending on the year, Ordinary level students must study one of Options 1A and 2A **or** one of Options 1B and 2B. The Higher level syllabus consists of a core and two options. Higher level students must study, in its entirety, either Option 1 or Option 2. Ordinary level students are required to study a lesser range of topics than Higher level students, and in less depth. All of the Ordinary level material, except mandatory experiment 4.2A, forms part of the Higher level course. Within both the core and the options, black text indicates the material that is designated Higher level only.

The syllabus is presented in an expanded format. It consists of four columns:

- content
- depth of treatment
- activities
- social and applied aspects.

The social and applied aspects of chemistry are an integral part of the syllabus and constitute 30% of the syllabus.

1.4 CONTENT

The core includes:

- periodic table and atomic structure
- chemical bonding
- stoichiometry and formulas and equations
- acids and bases
- volumetric analysis
- thermochemistry
- organic chemistry
- rates of reaction
- chemical equilibrium
- water chemistry.

Option 1A is additional industrial chemistry; option 1B is atmospheric chemistry; option 2A is materials, and option 2B is extraction of metals and additional electrochemistry. Some content from the previous (1983) syllabus has been deleted, and some new content has been added.
In addition, there has been a substantial re-arrangement of content under different headings.
A detailed list of additions to and deletions from the former syllabus is provided in appendix I.

The number of types of mathematical problems at Ordinary level has been reduced and a number of more difficult topics have been eliminated (e.g. electron pair repulsion theory). These measures, along with the increased emphasis on practical work and the social and applied aspects, should help to attract more Ordinary level students.

In the drawing up of the revised syllabus, the fact that both Ordinary and Higher level students will normally be in the same class has been borne in mind.

1.5 TEACHING APPROACH

Given that the reality in most schools is that there are mixed classes of Ordinary and Higher level students, there is a need to concentrate on issues in classroom management and teaching strategies so that Ordinary level students feel positive about the experience. Teachers should be able to give equal emphasis to Ordinary level and Higher level students so that both groups enjoy, and gain from, the experience. Contributions of Ordinary level students should be encouraged and valued as being of equal importance to those of Higher level students. Students should know what is expected of them for each topic, so that they are challenged and motivated (but, especially for Ordinary level students, so that they are not overextended and demotivated). Teachers should demystify the subject and make it attractive to students at both levels. This is a challenge to chemistry teachers that must be accepted if the numbers taking the subject are to increase and if a greater number of students are to have a satisfactory experience, which will encourage them to promote chemistry as a viable option for future Leaving Certificate students.

The syllabus should be taught in a practical and experimental way. Practical work is now a priority: for the first time there are mandatory experiments (28 at Higher level, 21 at Ordinary level). The mandatory experiments are listed at the end of each section of the syllabus. An adequate record of each student's practical work must be retained for the period of the course. Throughout the syllabus, additional activities, including teacher demonstrations, are listed.

The recommended time needed to teach each sub-section of the syllabus is indicated at the beginning of the relevant sub-section. This specification is intended only to indicate the *approximate* amount of time needed. The syllabus should be taught in a way that reflects the balance between pure chemistry (70%) and social and applied aspects of chemistry (30%). The syllabus does not necessarily prescribe the teaching order.

1.6 RESOURCES

The implementation of the revised Leaving Certificate Chemistry course involves in the main the use of equipment and chemicals required by the previous syllabus. However, there are some additional implications for resources. The inclusion of a colorimetric experiment necessitates the purchase of a colorimeter or comparators by each school offering chemistry as a Leaving Certificate subject. Additional resource materials dealing with topics such as instrumentation and industrial case studies are needed to ensure the effective teaching of these topics. Funds are required for necessary reference books and periodicals. A visit by each student to a chemical industry or a water treatment plant is recommended, and this also has resource implications. A small number of chemicals that are not at present being used in schools are required. The normal maintenance and replacement, where necessary, of laboratory equipment, and the replacement of consumables such as chemicals, are also required.

A list of the chemicals and equipment needed for the implementation of the course can be found in appendix 2 and appendix 3.

Laboratory access for at least one double period per week is essential for the full implementation of the syllabus. The availability of a television and video recorder is desirable. The availability of computer equipment, including datalogging equipment, specifically for use in the teaching of chemistry and the other sciences is assumed.

1.7 TIMETABLING

The syllabus requires approximately 180 hours of actual class teaching time over two years. This suggests five forty-minute periods per week and this includes the time required for students' practical work but excludes time lost to other school activities. It would be necessary to timetable at least two of these periods together to allow the students sufficient time to carry out the necessary practical work.

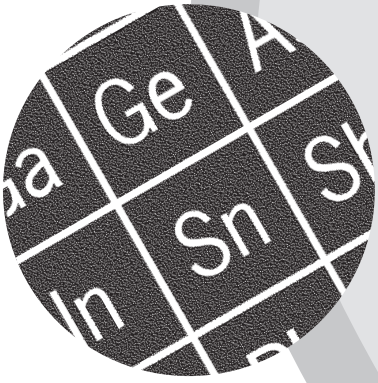
1.8 CHANGES COMPARED WITH THE FORMER SYLLABUS

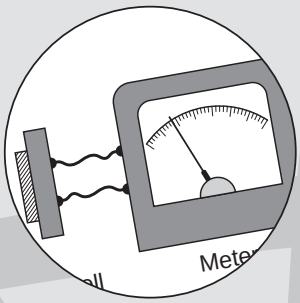
The main changes in the revised syllabus can be summarised as follows:

1. The revised syllabus is an expanded syllabus, rather than an outline syllabus.
2. The material is presented differently in the revised syllabus, in a four-column arrangement.
3. Ordinary level and Higher level syllabuses are presented.
4. Several of the section headings in the previous syllabus have been changed, with a consequent rearrangement of the content.
5. There are many changes in content.
6. There are some changes in the experiments prescribed for the course.
7. There is a list of mandatory experiments.
8. There is a greater emphasis on social and applied aspects.

A detailed list of additions and deletions, compared with the former syllabus, can be found in appendix 1.

Section two
social and applied aspects





2.1 INTRODUCTION

The integration of social and applied aspects within the chemistry syllabus is an important change in the revised syllabus. The teaching of the new course should reflect this; the examination paper will reflect the balance between pure chemistry (70%) and social and applied aspects (30%). The social and applied aspects are intended to capture students' imagination and to encourage them to explore chemical concepts from a broader viewpoint.

Chemistry as a subject in the senior cycle curriculum serves a number of functions. One is to familiarise students with chemistry, and to interest them in proceeding with further studies in chemistry. Another is to prepare them for careers for which chemistry is a basic component, such as chemical engineering, civil engineering, medicine, pharmacy, dentistry, veterinary medicine, laboratory technician, and nursing. Yet another function is to help them understand the world in which they live. A command of the concepts of chemistry explains many of the wonders of our everyday lives. A further function is to help them develop an understanding of concepts that they, as citizens, may have to consider, particularly in relation to environmental issues, such as the location of industries. The increased emphasis on social and applied aspects of chemistry is relevant to each of these functions.

2.2 REFERENCES

Some references for the major social and applied aspects included in the syllabus are listed below. In the case of the Teacher's Reference Handbook (Department of Education and Science, 2000), page reference numbers are given for both the printed version and the CD Rom version.

(Underlined topics are for Higher level only.)

CORE
SYLLABUS SECTION 1.1

Topic	References
History of the idea of elements	1. *The Fontana History of Chemistry* William H. Brock (Fontana Press, 1992). 2. "History of the idea of elements" (Leaving Certificate Physics and Chemistry Support Service, 1999).
History of the periodic table	1. *The Fontana History of Chemistry* William H. Brock (Fontana Press, 1992). 2. Teacher's Reference Handbook: Chemistry Module 1: *Atomic Structure and Trends in the Periodic Table of the Elements* Chapter 2 pp. 43-48 (Department of Education and Science, 2000) (CD pp. 64-69)

SYLLABUS SECTION 1.2

Topic	References
Very brief outline of the historical development of atomic theory	1. *The Fontana History of Chemistry* William H. Brock (Fontana Press, 1992). 2. Teacher's Reference Handbook: Chemistry Module 1: *Atomic Structure and Trends in the Periodic Table of the Elements* Chapter 1 pp. 3-7, 9-15, 21 (Department of Education and Science, 2000) (CD pp. 24-28; 30-36; 42)
Other topics	1. *Instrumentation* Teacher Guidelines (see section 3). 2. Teacher's Reference Handbook: Chemistry Module 1: *Atomic Structure and Trends in the Periodic Table of the Elements* Chapter 1 pp. 21-23 (Department of Education and Science, 2000) (CD pp. 42-44) 3. "Mass Spectrometry"(Leaving Certificate Physics and Chemistry Support Service, 1999).

SYLLABUS SECTION 1.3

Topic	References
Historical outline of radioactivity	1. Teacher's Reference Handbook: Chemistry Module 1: *Atomic Structure and Trends in the Periodic Table of the Elements* Chapter 1 pp. 7-9; chapter 2 p. 40 (Department of Education and Science, 2000) (CD pp. 28-30; 62) 2. *Serendipity: Accidental Discoveries in Science* by Royston M. Roberts (John Wiley 1989), pp. 143-146. 3. "Radioactivity"(Leaving Certificate Physics and Chemistry Support Service, 2000).
Widespread occurrence of radioactivity	Technology Ireland, May 1990, p. 49-53: *Radioactivity in the Irish marine environment.*
Food irradiation	1. Technology Ireland, June 1987, p. 45-47: *Irradiation of fruits and vegetables.* 2. "Radioactivity"(Leaving Certificate Physics and Chemistry Support Service, 2000).
Other uses of radioisotopes	"Radioactivity"(Leaving Certificate Physics and Chemistry Support Service, 2000).

SYLLABUS SECTION 1.4

Topic	References
Atomic absorption spectrometry	1. *Instrumentation* Teacher Guidelines (see section 3). 2. Teacher's Reference Handbook: Chemistry Module 4: *Environmental Chemistry – Water* Chapter 3 pp. 52-53 (Department of Education and Science, 2000) (CD pp. 249-250)
Fireworks	"Fireworks" (Leaving Certificate Physics and Chemistry Support Service, 2000).

SYLLABUS SECTION 1.5

Topic	References
Rusting of iron	Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 3 p. 51 (Department of Education and Science, 2000) (CD p. 593)
Swimming-pool water treatment	1. *SATIS 16-19*, unit 66 (Association for Science Education, 1992). 2. "Swimming Pool Water Treatment/ Bleaching" (Leaving Certificate Physics and Chemistry Support Service, 2000).
Use of scrap iron to extract copper	*The Extraction of Metals* (ISTA Chemistry booklet no. 3, 1986), p. 170.
Purification of copper	*The Extraction of Metals* (ISTA Chemistry booklet no. 3, 1986), p. 168.

SYLLABUS SECTION 2.6

Topic	References
Bleaches as oxidising agents or reducing agents	1. *SATIS 16-19*, unit 42 (Association for Science Education, 1992). 2. "Swimming Pool Water Treatment/ Bleaching" (Leaving Certificate Physics and Chemistry Support Service, 2000).

SYLLABUS SECTION 3.3

Topic	References
M_r determination using a mass spectrometer	1. *Instrumentation* Teacher Guidelines (see section 3). 2. Teacher's Reference Handbook: Chemistry Module 1: *Atomic Structure and Trends in the Periodic Table of the Elements* Chapter 1 p. 23 (Department of Education and Science, 2000) (CD p. 44)

SYLLABUS SECTION 5.1

Topic	References
Decomposition of animal waste and vegetation as methane sources	1. *Energy Conservation and the Environment* (Forbairt, 1993). Articles section pp. 7-10, 130-137. 2. *SATIS 16-19*, unit 63 (Association for Science Education, 1992). 3. Teacher's Reference Handbook: Chemistry Module 2: *Hydrocarbons* Chapter 3 pp. 22-23 (Department of Education and Science, 2000) (CD pp. 112-113)
Methane as a contributor to the greenhouse effect	Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 2 pp. 9-10 (Department of Education and Science, 2000) (CD pp. 515-516)

SYLLABUS SECTION 5.4

Topic	References
Kilogram calorific values of fuels and their uses	Teacher's Reference Handbook: Chemistry Module 7: *Stoichiometry II* Chapter 1 pp. 6-7 (Department of Education and Science, 2000) (CD pp. 407-408)

SYLLABUS SECTION 5.5

Topic	References
Fractionation of crude oil. Uses of the refinery gas, light gasoline, naphtha, kerosene, gas oil and residue fractions	Teacher's Reference Handbook: Chemistry Module 2: *Hydrocarbons* Chapter 2 pp. 10-11 (Department of Education and Science, 2000) (CD pp. 100-101)
Composition of natural gas and liquid petroleum gas (LPG)	1. *Energy Conservation and the Environment* (Forbairt, 1993), Fuels section, p. 28. 2. Teacher's Reference Handbook: Chemistry Module 2: *Hydrocarbons* Chapter 2 p. 10 (Department of Education and Science, 2000) (CD p. 100)
Addition of mercaptans to natural gas	Teacher's Reference Handbook: Chemistry Module 2: *Hydrocarbons* Chapter 2 p. 11 (Department of Education and Science, 2000) (CD p. 101)
Composition of petrol	1. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), pp. 23-25. 2. Teacher's Reference Handbook: Chemistry Module 2: *Hydrocarbons* Chapter 2 p. 17 (Department of Education and Science, 2000) (CD p. 107)
Auto-ignition	1. S*alters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), p. 26. 2. Teacher's Reference Handbook: Chemistry Module 2: *Hydrocarbons* Chapter 2 p. 17 (Department of Education and Science, 2000) (CD p. 107)
Octane numbers	1. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), p. 26. 2. "Petrol and Octane Numbers"(Leaving Certificate Physics and Chemistry Support Service, 1999). 3. Teacher's Reference Handbook: Chemistry Module 2: *Hydrocarbons* Chapter 2 pp. 17-18, 20 (Department of Education and Science, 2000) (CD pp. 107-108, 110)

Topic	References
Internal combustion engine in relation to auto-ignition	1. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), p. 26. 2. "Petrol and Octane Numbers"(Leaving Certificate Physics and Chemistry Support Service, 1999).
Relationship between octane number and **(i) degree of branching** **(ii) chain length** **(iii) cyclic structure pp. 27, 29.**	*Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000),
Lead in petrol	1. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), p. 27. 2. Teacher's Reference Handbook: Chemistry Module 2: *Hydrocarbons* Chapter 2 pp. 18-19 (Department of Education and Science, 2000) (CD pp. 108-109)
Alternatives to lead in petrol: improving octane number by 2000), **(i) isomerisation pp. 27-30.** **(ii) dehydrocyclisation** **(iii) catalytic cracking**	1. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2. "Petrol and Octane Numbers"(Leaving Certificate Physics and Chemistry Support Service, 1999). 3. Teacher's Reference Handbook: Chemistry Module 2: *Hydrocarbons* Chapter 2 pp. 12-14 (Department of Education and Science, 2000) (CD pp. 102-104)
Adding oxygenates to petrol	1. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), p. 31. 2. "Petrol and Octane Numbers" (Leaving Certificate Physics and Chemistry Support Service, 1999). 3. Teacher's Reference Handbook: Chemistry Module 2: *Hydrocarbons* Chapter 2 p. 19 (Department of Education and Science, 2000) (CD p. 109)

SYLLABUS SECTION 5.6

Topic	References
Potential of hydrogen as a fuel	*New Scientist: Inside Science*, no. 68, 15 January 1994.

SYLLABUS SECTION 6.2

Topic	References
Dust explosions	Teacher's Reference Handbook: Chemistry Module 7: *Stoichiometry II* Chapter 1 pp. 10, 26-27 (Department of Education and Science, 2000) (CD pp. 411, 427-428)
Catalytic converters	1. *SATIS 16-19*, unit 65 (Association for Science Education, 1992). 2. *Chemistry in Action*, vol. 36 (spring 1992), p. 36-37. 3. Teacher's Reference Handbook: Chemistry Module 7: *Stoichiometry II* Chapter 1 p. 9 (Department of Education and Science, 2000) (CD p. 410) 4. Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 3 pp. 24-25 (Department of Education and Science, 2000) (CD pp. 530-531)
Enzymes	Teacher's Reference Handbook: Chemistry Module 7: *Stoichiometry II* Chapter 2 pp. 43-44 (Department of Education and Science, 2000) (CD pp. 444-445)
Catalyst poisons	Teacher's Reference Handbook: Chemistry Module 7: *Stoichiometry II* Chapter 2 p. 42 (Department of Education and Science, 2000) (CD p. 443)

SYLLABUS SECTION 7.1

Topic	References
Ethanol as a solvent	1. *Organic Chemicals in Everyday Life* (ISTA Chemistry Booklet no. 5, 1988), p. 100. 2. Teacher's Reference Handbook: Chemistry Module 6: *Alcohols, Aldehydes, Ketones and Carboxylic Acids* Chapter 1 p. 9 (Department of Education and Science, 2000) (CD p. 347)

Topic	References
Fermentation	Teacher's Reference Handbook: Chemistry Module 6: *Alcohols, Aldehydes, Ketones and Carboxylic Acids* Chapter 1 pp. 10-18 (Department of Education and Science, 2000) (CD pp. 348-356)
Methanol as a denaturing agent	Teacher's Reference Handbook: Chemistry Module 6: *Alcohols, Aldehydes, Ketones and Carboxylic Acids* Chapter 1 p. 9 (Department of Education and Science, 2000) (CD p. 347)

SYLLABUS SECTION 7.2

Topic	References
Benzaldehyde in almond kernels	Teacher's Reference Handbook: Chemistry Module 6: *Alcohols, Aldehydes, Ketones and Carboxylic Acids* Chapter 2 p. 36 (Department of Education and Science, 2000) (CD p. 374)
Propanone as a solvent	1. *Organic Chemicals in Everyday Life* (ISTA Chemistry Booklet no. 5, 1988), p. 100. 2. Teacher's Reference Handbook: Chemistry Module 6: *Alcohols, Aldehydes, Ketones and Carboxylic Acids* Chapter 2 p. 37 (Department of Education and Science, 2000) (CD p. 375)
Methanoic acid in nettles and ants	1. *Organic Chemicals in Everyday Life* (ISTA Chemistry Booklet no. 5, 1988), p. 44. 2. Teacher's Reference Handbook: Chemistry Module 6: *Alcohols, Aldehydes, Ketones and Carboxylic Acids* Chapter 3 p. 49 (Department of Education and Science, 2000) (CD p. 387)
Ethanoic acid in vinegar	1. *Organic Chemicals in Everyday Life* (ISTA Chemistry Booklet no. 5, 1988), p. 44. 2. Teacher's Reference Handbook: Chemistry Module 6: *Alcohols, Aldehydes, Ketones and Carboxylic Acids* Chapter 3 p. 49 (Department of Education and Science, 2000) (CD p. 387)
Use of ethanoic acid in the manufacture of cellulose acetate	Teacher's Reference Handbook: Chemistry Module 6: *Alcohols, Aldehydes, Ketones and Carboxylic Acids* Chapter 3 p. 49 (Department of Education and Science, 2000) (CD p. 387)

Topic	References
Use of carboxylic acids and their salts as food preservatives	Teacher's Reference Handbook: Chemistry Module 6: *Alcohols, Aldehydes, Ketones and Carboxylic Acids* Chapter 3 pp. 49-50 (Department of Education and Science, 2000) (CD pp. 387-388)
Fats as natural esters	1. *Organic Chemicals in Everyday Life* (ISTA Chemistry Booklet no. 5, 1988), p. 47. 2. Teacher's Reference Handbook: Chemistry Module 6: *Alcohols, Aldehydes, Ketones and Carboxylic Acids* Appendix A p.58 (Department of Education and Science, 2000) (CD p. 396)
Ethyl ethanoate as a solvent	*Organic Chemicals in Everyday Life* (ISTA Chemistry Booklet no. 5, 1988), p. 99.
Aromas of esters	1. *Organic Chemicals in Everyday Life* (ISTA Chemistry Booklet no. 5, 1988), p. 57-59. 2. Teacher's Reference Handbook: Chemistry Module 6: *Alcohols, Aldehydes, Ketones and Carboxylic Acids* Chapter 1 p. 22 (Department of Education and Science, 2000). (CD p. 360)
Carcinogenic nature of some aromatic compounds	Teacher's Reference Handbook: Chemistry Module 2: *Hydrocarbons* Chapter 2 pp. 19-20 (Department of Education and Science, 2000) (CD pp. 109-110)

SYLLABUS SECTION 7.3

Topic	References
Industrial importance of hydrogenation of vegetable oils	1. *Organic Chemicals in Everyday Life* (ISTA Chemistry Booklet no. 5, 1988), p. 51. 2. Teacher's Reference Handbook: Chemistry Module 2: *Hydrocarbons* Chapter 4 p. 43 (Department of Education and Science, 2000) (CD p. 133)
Alkenes as raw materials in the industrial manufacture of plastics	Teacher's Reference Handbook: Chemistry Module 2: *Hydrocarbons* Chapter 4 pp. 47-48 (Department of Education and Science, 2000) (CD pp.137-138)
Soap manufacture	*Organic Chemicals in Everyday Life* (ISTA Chemistry Booklet no. 5, 1988), pp. 61-65.

Topic	References
Ethanal formation in the metabolism of ethanol in the human body	Teacher's Reference Handbook: Chemistry Module 6: *Alcohols, Aldehydes, Ketones and Carboxylic Acids* Chapter 1 p. 9 (Department of Education and Science, 2000) (CD p. 347)
Alcohols as motor fuels	*SATIS 16-19*, unit 81 (Association for Science Education, 1992).

SYLLABUS SECTION 7.5

Topic	References
All topics	*Instrumentation* Teacher Guidelines (see section 3).
Uses of chromatographic techniques	"Chromatography"(Leaving Certificate Physics and Chemistry Support Service, 2000).

SYLLABUS SECTION 8.2

Topic	References
Industrial applications of Le Chatelier's principle	1. *Rates of Reaction and Equilibrium* (ISTA Chemistry Booklet no. 1, 1984), p. 46-48. 2. Teacher's Reference Handbook: Chemistry Module 7: *Stoichiometry II* Chapter 3 p. 66 (Department of Education and Science, 2000) (CD p. 467)

SYLLABUS SECTION 9.2

Topic	References
Removal of hardness from water	Teacher's Reference Handbook: Chemistry Module 4: *Environmental Chemistry – Water* Chapter 2 pp. 20-23 (Department of Education and Science, 2000) (CD pp.217-220)

SYLLABUS SECTION 9.3

Topic	References
Water treatment	Teacher's Reference Handbook: Chemistry Module 4: *Environmental Chemistry – Wate*r Chapter 3 pp. 32-37 (Department of Education and Science, 2000) (CD pp. 229-234)
Sewage treatment	Teacher's Reference Handbook: Chemistry Module 4: *Environmental Chemistry – Wate*r Chapter 3 pp. 41-46 (Department of Education and Science, 2000) (CD pp. 238-243)
Eutrophication	Teacher's Reference Handbook: Chemistry Module 4: *Environmental Chemistry – Water* Chapter 3 pp. 47-50 (Department of Education and Science, 2000) (CD pp. 244-247)
Awareness that there are EU limits for various chemical species in water	'Drinking Water' unit *Science Across Europe*, (Association for Science Education).

SYLLABUS SECTION 9.4

Topic	References
Organic chemical pollutants in water	*Chemistry in Action* vol. 35 (autumn 1991), pp. 26-34.
Other topics	*Instrumentation* Teacher Guidelines (see section 3).
Atomic absorption spectrometry	Teacher's Reference Handbook: Chemistry Module 4: *Environmental Chemistry – Water* Chapter 3 pp. 52-53 (Department of Education and Science, 2000) (CD pp. 249-250)

OPTIONS

SYLLABUS SECTION 1A.1

Topic	References
Awareness of the contributions of chemistry to society	Teacher's Reference Handbook: Chemistry Module 3: *Industrial Chemistry* Chapter 1 p. 5 (Department of Education and Science, 2000) (CD p. 162)
General principles of industrial chemistry	1. *Industrial Chemistry (General Principles) and Industrial Visits* Teacher Guidelines (see section 4). 2. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), p. 286-296.
Industrial visits	1. *Industrial Chemistry (General Principles) and Industrial Visits* Teacher Guidelines (see Section 4). 2. *The Chemical Industry in Ireland: A Directory for Teachers* by Peter Childs and Marie Walsh (Schools Information Centre on the Irish Chemical Industry, 1989).

SYLLABUS SECTION 1A.2

Topic	References
Awareness of the range and scope of the Irish chemical industry	1. *The Chemical Industry in Ireland: A Directory Teachers* by Peter Childs and Marie Walsh (Schools Information Centre on the Irish Chemical Industry, 1989). 2. Teacher's Reference Handbook: Chemistry Module 3: *Industrial Chemistry* Chapter 1 p. 5 (Department of Education and Science, 2000) (CD p.162)
INDUSTRIAL CASE STUDIES:	
(a) Ammonia and urea manufacture	1. "Industrial Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000). 2. Teacher's Reference Handbook: Chemistry Module 3: *Industrial Chemistry* Chapter 2 pp. 7-12 (Department of Education and Science, 2000) (CD pp. 164-169)

Topic	References
(b) Nitric acid manufacture	1. "Manufacture of Nitric Acid and Calcium Ammonium Nitrate" (Leaving Certificate Physics and Chemistry Support Service, 2001). 2. Teacher's Reference Handbook: Chemistry Module 3: *Industrial Chemistry* Chapter 3 pp. 13-21 (Department of Education and Science, 2000 (CD pp. 170-178)
(c) Magnesium oxide manufacture	1. "Premier Periclase Case Study" (Leaving Certificate Physics and Chemistry Support Service, 2000) 2. Teacher's Reference Handbook: Chemistry Module 3: *Industrial Chemistry* Chapter 4 pp. 25-37 (Department of Education and Science, 2000) (CD pp. 182-194).

SYLLABUS SECTION 1B.1

Topic	References
Manufacture of oxygen	Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 1 pp3-4 (Department of Education and Science, 2000) (CD pp. 509-510).
Uses of liquid nitrogen	Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 1 p. 4 (Department of Education and Science, 2000) (CD p. 510).

SYLLABUS SECTION 1B.2

Topic	References
Uses of nitrogen	Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 1 p. 4 (Department of Education and Science, 2000) (CD p. 510).

SYLLABUS SECTION 1B.3

Topic	References
Carbon monoxide as a poison	Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 3 pp. 20-21(Department of Education and Science, 2000) (CD pp. 526-527).

Topic	References
The greenhouse effect	1. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000). 2. *Energy Conservation and the Environment* (Forbairt, 1993) Energy and the Environment section, pp. 21-22. 3. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), pp. 79-82. 4. Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 2 pp. 7-8 (Department of Education and Science, 2000 (CD pp. 513-514)
Greenhouse gases and their relative effects	1. *Energy Conservation and the Environment* (Forbairt, 1993), Energy and the Environment section, pp. 21-22. Articles section pp. 41-44. 2. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), pp. 81-82. 3. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000). 4. Teacher's Reference Handbook: Chemistry Module 8:*Atmospheric Chemistry* Chapter 2 pp. 8-10 (Department of Education and Science, 2000) (CD pp. 514-516).
Reduction of atmospheric carbon dioxide by dissolving in the oceans	1. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), pp. 87-88. 2. *Energy Conservation and the Environment* (Forbairt 1993). Articles section, p. 42. 3. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000).
Possible implications of the increased greenhouse effect	1. *Energy Conservation and the Environment* (Forbairt, 1993), Energy and the Environment section, pp. 21-22. Articles section, pp. 161-162. 2. Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 2 pp. 11-17 (Department of Education and Science, 2000) (CD pp. 517-523) 3. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000).

SYLLABUS SECTION 1B.4

Topic	References
Acid rain and its effects on the environment	1. *Energy Conservation and the Environment* (Forbairt, 1993), Energy and the Environment section, pp. 14-15, 20. Articles section pp. 1-4. 2. *SATIS 16-19*, unit 95 (Association for Science Education, 1992). 3. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000). 4. Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 3 pp. 21-22 (Department of Education and Science, 2000) (CD pp. 527-528)

SYLLABUS SECTION 1B.5

Topic	References
Formation of ozone in the stratosphere	1. *Energy Conservation and the Environment* (Forbairt, 1993), Energy and the Environment section, p. 23. Articles section, p. 92. 2. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), pp. 66-67. 3. Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 4 p. 29 (Department of Education and Science, 2000) (CD p. 535) 4. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000).
Beneficial effect of the ozone layer	1. *Energy Conservation and the Environment* (Forbairt 1993), Energy and the Environment section, p. 23. Articles section, p. 93. 2. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), p. 66. 3. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000). 4. Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 4 p.28 (Department of Education and Science, 2000) (CD p. 534)

Topic	References
Photodissociation of ozone	1. *Energy Conservation and the Environment* (Forbairt 1993), Energy and the Environment section, p. 23; Articles section, p. 92. 2. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), p. 67. 3. Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 4 p. 29 (Department of Education and Science, 2000) (CD p. 535) 4. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000).
Uses of CFCs	1. *Energy Conservation and the Environment* (Forbairt 1993). Articles section, pp. 101-103. 2. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), pp. 75-76 . 3. *SATIS 16-19*, unit 12 (Association for Science Education, 1992). 4. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000). 5. Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 4 p. 30 (Department of Education and Science, 2000) (CD p. 536)
Residence times of CFCs	*Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), pp. 75-76.
Breakdown of CFCs in the stratosphere	1. *Salters Advanced Chemistry*: Chemical Storylines (second edition) (Heinemann, 2000), p. 72. 2. *SATIS 16-19*, unit 12 (Association for Science Education, 1992) 3. Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 4 p. 31 (Department of Education and Science, 2000) (CD p. 537) 4. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000).

Topic	References
Removal of ozone	1. *Energy Conservation and the Environment* (Forbairt, 1993), Energy and the Environment section, p. 23-24. 2. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), pp. 68-69. 3. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000). 4. Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 4 pp. 31- 34 (Department of Education and Science, 2000) (CD pp. 537-540)
Role of methane in absorbing Cl atoms	1. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), pp. 76-77. 2. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000).
CFCs are believed to be the main cause of damage to the ozone layer	1. *Energy Conservation and the Environment* (Forbairt, 1993), Energy and the Environment section, pp. 23-24. 2. Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 4 pp. 31-32 (Department of Education and Science, 2000) (CD pp. 537-538) 3. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000).
Effects of damage to the ozone layer	1. *Energy Conservation and the Environment* (Forbairt, 1993), Energy and the Environment section, pp. 23-24. 2. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), pp. 77-79. 3. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000). 4. Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 4 pp. 27-29 (Department of Education and Science, 2000) (CD pp. 533-535)

Topic	References
Replacements for CFCs	1. *SATIS 16-19*, unit 12 (Association for Science Education, 1992). 2. Teacher's Reference Handbook: Chemistry Module 8: *Atmospheric Chemistry* Chapter 4 pp. 32- 33 (Department of Education and Science, 2000) (CD pp. 538-539) 3. "Atmospheric Chemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000).

SYLLABUS SECTION 2A.1

Topic	References
All topics	1. *Instrumentation* Teacher Guidelines (see section 3). 2. "Crystals" (Leaving Certificate Physics and Chemistry Support Service, 2000).
Contributions of the Braggs	Teacher's Reference Handbook: Chemistry Module 5: *Stoichiometry I* Chapter 1 pp. 6-8 (Department of Education and Science, 2000) (CD pp. 267-269)
Contributions of Dorothy Hodgkin	Teacher's Reference Handbook: Chemistry Module 5: *Stoichiometry I* Chapter 1 p. 8 (Department of Education and Science, 2000) (CD p. 269)
Discovery of buckminsterfullerene	Teacher's Reference Handbook: Chemistry Module 5: *Stoichiometry I* Chapter 1 p. 4 (Department of Education and Science, 2000) (CD p. 265)

SYLLABUS SECTION 2A.2

Topic	References
Uses of polymers	1. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 1 pp. 3-4 (Department of Education and Science, 2000) (CD pp. 545-546) 2. "Polymers" (Leaving Certificate Physics and Chemistry Support Service, 2000).

Topic	References
Brief history of the discovery of low-density poly(ethene)	1. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), pp. 94-96. 2. *Serendipity: Accidental Discoveries in Science* by Royston M. Roberts (John Wiley, 1989), pp. 177-181. 3. "Polymers" (Leaving Certificate Physics and Chemistry Support Service, 2000). 4. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 1 pp. 6-7 (Department of Education and Science, 2000) (CD pp. 548-549)
Brief history of the discovery of high-density poly(ethene)	1. *Salters Advanced Chemistry: Chemical Storylines* (second edition) (Heinemann, 2000), pp. 96-98. 2. Serendipity: Accidental Discoveries in Science by Royston M. Roberts (John Wiley 1989) pp. 182-185. 3. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 1 pp. 7-9 (Department of Education and Science, 2000) (CD pp. 549-551) 4. "Polymers" (Leaving Certificate Physics and Chemistry Support Service, 2000).
Brief history of the discovery of PTFE/poly(tetrafluroethene)	1. *Serendipity: Accidental Discoveries in Science* by Royston M. Roberts (John Wiley 1989), pp. 187-191. 2. "Polymers" (Leaving Certificate Physics and Chemistry Support Service, 2000). 3. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 1 pp. 9-10 (Department of Education and Science, 2000) (CD pp. 551-552)
Recycling of plastics	1. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 1 pp. 15-18 (Department of Education and Science, 2000) (CD pp. 557-560) 2. "Polymers" (Leaving Certificate Physics and Chemistry Support Service, 2000).

SYLLABUS SECTION 2A.3

Topic	References
Carbon in steel and hardness	1. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 3 pp. 49-50 (Department of Education and Science, 2000) (CD pp. 591-592) 2. "Steel" (Leaving Certificate Physics and Chemistry Support Service, 2000).

SYLLABUS SECTION 2B.1

Topic	References
Contributions of Galvani, Volta, Davy and Faraday	1. *Serendipity: Accidental Discoveries in Science* by Royston M. Roberts (John Wiley 1989), p. 16-18. 2. "Early History of Electrochemistry" (Leaving Certificate Physics and Chemistry Support Service, 2000). 3. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 2 pp. 20- 21 (Department of Education and Science, 2000) (CD pp. 562-563)

SYLLABUS SECTION 2B.3

Topic	References
Corrosion prevention	Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 2 pp. 28-29 (Department of Education and Science, 2000) (CD pp. 570-571)
Sacrificial anodes	Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 2 p. 29 (Department of Education and Science, 2000) (CD p. 571)

SYLLABUS SECTION 2B.4

Topic	References
Manufacture of sodium	1. *The Extraction of Metals* (ISTA Chemistry Booklet no. 3), pp. 114-115. 2. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 2 p. 31 (Department of Education and Science, 2000) (CD p. 573)

Topic	References
Uses of sodium	1. *The Extraction of Metals* (ISTA Chemistry Booklet no. 3), p. 116. 2. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 2 p. 31 (Department of Education and Science, 2000) (CD p. 573)
Manufacture of aluminium	1. *The Extraction of Metals* (ISTA Chemistry Booklet no. 3), p. 127-132. 2. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 2 pp. 32-34 (Department of Education and Science, 2000) (CD pp. 574-576)
Uses of aluminium	1. *The Extraction of Metals* (ISTA Chemistry Booklet no. 3), p. 132. 2. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 2 p. 34 (Department of Education and Science, 2000) (CD p. 576)
Chlorine is an important by-product of sodium production	*The Extraction of Metals* (ISTA Chemistry Booklet no. 3), p. 114.
Environmental aspects of aluminium production	1. *Chemistry in Action*, vol. 15, p. 17, 1985. 2. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 2 p. 34 (Department of Education and Science, 2000) (CD p. 576)
Economics of cheap electricity in the extraction of aluminium	1. Chemistry in Action, vol. 15, p. 14, 1985. 2. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 2 pp. 33-34 (Department of Education and Science, 2000) (CD pp. 575-576)
Porous nature of the oxide layer formed by anodising	1. *Chemistry in Action*, vol. 15, p. 22, 1985. 2. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 2 pp. 34-35 (Department of Education and Science, 2000) (CD pp. 576-577)
Recycling of aluminium	Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 2 p. 34 (Department of Education and Science, 2000) (CD p. 576)

SYLLABUS SECTION 2B.5

Topic	References
Manufacture of iron and steel	1. *The Extraction of Metals* (ISTA Chemistry Booklet no. 3), p. 152-163. 2. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 3 pp. 48-50 (Department of Education and Science, 2000) (CD pp. 590-592)
Uses of iron	1. *The Extraction of Metals* (ISTA Chemistry Booklet no. 3.), p. 163. 2. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 3 p. 49 (Department of Education and Science, 2000) (CD p. 591)
Uses of steel	*The Extraction of Metals* (ISTA Chemistry Booklet no. 3), p. 163.
Electric arc process for steel manufacture	1. *From Scrap Iron to Structural Steel* (Booklet and videotape), Irish Steel. 2. Teacher's Reference Handbook: Chemistry Module 9: *Materials* Chapter 3 p. 50 (Department of Education and Science, 2000) (CD p. 592) 3. "Steel" (Leaving Certificate Physics and Chemistry Support Service, 2000).
Environmental aspects of iron and steel production	"Steel" (Leaving Certificate Physics and Chemistry Support Service, 2000).

2.3 MAGAZINES AND JOURNALS

(Several of the periodicals listed below are available at a reduced rate to subscribers to the Royal Society of Chemistry Schools Publication Service. For more information about this service contact: Education Officer, Schools and Colleges, Royal Society of Chemistry, Burlington House, Piccadilly, London WV OBN1, England.)

Chemistry in Action

(available from Dr Peter Childs, University of Limerick, Limerick).

3 issues per annum.

Free to teachers of chemistry in Ireland who are registered on the mailing list. Included in the RSC Schools Publication Service.

Chem 13 News

(Canadian)

10 issues per annum.

Included in the RSC Schools Publication Service.

Education in Chemistry

(published by the Royal Society of Chemistry).

6 issues per annum.

Included in the RSC Schools Publication Service.

Science

(published by the Irish Science Teachers' Association).

3 issues per annum.

School Science Review

(published by the Association for Science Education in England).

4 issues per annum.

Free to ASE members.

Chemmatters

(published by the American Chemical Society).

4 issues per annum.

Included in the RSC Schools Publication Service.

Chemistry in Britain

(published by the Royal Society of Chemistry).

12 issues per annum.

Free to RSC members.

Technology Ireland

(published by Forfás).

11 issues per annum.

New Scientist

(published by IPC magazines).

Issued weekly.

These periodicals contain information relating to the pure chemistry components of the course, as well as to the social and applied aspects.

A more extensive list of periodicals may be found in *Resources for Teaching Chemistry: A Directory for Chemistry Teachers*, published by the Schools Information Centre on the Irish Chemical Industry, and compiled by Dr Peter Childs and Marie Walsh, University of Limerick, Limerick.

2.4 BOOKS

The following list includes the books listed in section 2.2 and some others that may be useful, especially in dealing with the newer components of the social and applied aspects. All these books contain relevant information about the pure chemistry components of the syllabus also. This is not an exhaustive list, and teachers are encouraged to develop a wide library of resource materials.

Brock, William H.

The Fontana History of Chemistry

(Fontana Press, 1992)

Childs, Peter, and Walsh, Marie

The Chemical Industry in Ireland: A Directory for Teachers

(Schools Information Centre on the Irish Chemical Industry)

Childs, Peter, and Walsh, Marie

Resources for Teaching Chemistry

(Schools Information Centre on the Irish Chemical Industry)

Flatow, Ira

They all laughed (Harper Perennial)

Forbairt

Energy Conservation and the Environment (Forbairt, 1993)

ISTA Chemistry Booklet no. 1

Rates of Reaction and Equilibrium

ISTA Chemistry Booklet no. 2

Oxidation - Reduction Reactions

ISTA Chemistry Booklet no. 3

The Extraction of Metals

ISTA Chemistry Booklet no. 4

Industrial Chemistry

ISTA Chemistry Booklet no. 5

Organic Chemicals in Everyday Life

Roberts, Royston M.

Serendipity: Accidental Discoveries in Science (John Wiley, 1989)

Salters Advanced Chemistry

Chemical Storylines (Heinemann, 2000)

Salters Advanced Chemistry

Activities and Assessment Pack (Heinemann, 2000)

Salters Advanced Chemistry

Teacher's Guide (Heinemann, 2000)

SATIS 16-19

(Association for Science Education, 1992)

Science Across Europe

(Association for Science Education)

2.5 INTERNET

An ever-growing number of useful resources for chemistry teaching is available on the internet. As web site references can rapidly go out of date, only a very limited number of references is included below. These are correct at the time of printing, but may change without notice. A more extensive list of references will be included in the web site edition of this document.

Examples of web sites include:

http://www.sigma-aldrich.com/

Material safety data sheets (MSDS) are available on this site.

http://www.rsc.org/

This site belongs to the Royal Society of Chemistry which contains many links to other useful sites.

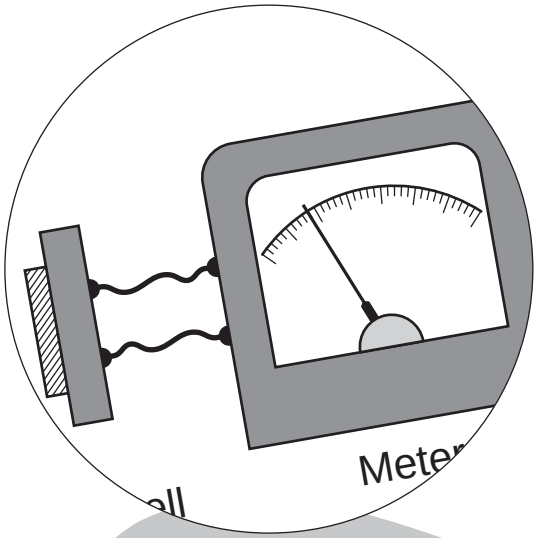
http://www.anachem.umu.se/eks/pointers.htm

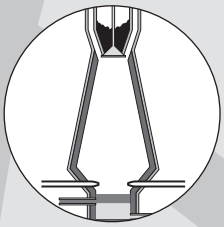
This site contains links to a comprehensive list of chemistry teaching resources on the internet, including demonstrations and experiments, the history of chemistry, and curiosities related to chemistry.

http://chemistry.rsc.org/rsc/chem-img.htm

This site contains listings and reviews of useful chemistry videotapes.

Section three instrumentation





3.1 INTRODUCTION

Section 3 gives information about the instrumentation referred to in various sections of the Leaving Certificate Chemistry syllabus. This material is being introduced for the first time, as it is a necessary component of a modern chemistry course. It is clearly not envisaged that schools will equip themselves with any of the instruments referred to here, other than a pH meter and a colorimeter. It is, however, likely that students will encounter the more advanced instruments during recommended visits to an industrial chemical plant or a water treatment plant. As indicated in the syllabus, a knowledge of only the basic principles of each instrument/technique is required. The interpretation of spectra etc. is not required.

3.2 INSTRUMENTATION

SYLLABUS SECTION 1.2

Instrument: Mass spectrometer

Ordinary level

The mass spectrometer is an instrument that is capable of separating and recording the relative amounts of the isotopes of an element. These amounts can be used to calculate the relative atomic mass of an element.

Higher level

In a mass spectrometer (Fig. 1 and Fig. 2), the sample to be analysed is "injected" into the instrument, where it is vaporised, and then ionised by bombardment with a beam of high-energy electrons. The positive ions produced in this way are then accelerated through a slit, using an electric field, and deflected along a circular path (the degree of curvature of which depends on the mass of the ion), using a magnetic field. In this way they are separated into beams of ions of similar masses, and then they are detected electronically.

Fig 1.

SYLLABUS SECTION 3.3

Instrument: Mass spectrometer

Higher level

A mass spectrometer can be used to determine accurately the relative molecular mass of a substance composed of molecules. In a mass spectrometer, molecules are ionised and broken into positively charged fragments with different masses (Figs. 3(i), 3(ii), 4 (i) and 4 (ii)). These are separated and the relative amounts recorded, giving the mass spectrum of the molecule. Usually, the mass spectrum of a molecule M contains the parent molecular ion M^+.

The mass of this ion is the same as the relative molecular mass of the molecule. (Note that in Fig. 4 (i) there is a peak at 17 relative atomic mass units, even though the relative molecular mass of methane is 16. This is due to methane containing the isotope ^{13}C, which constitutes about 1.1% of natural carbon.)

(Note that the interpretation of mass spectra is not required.)

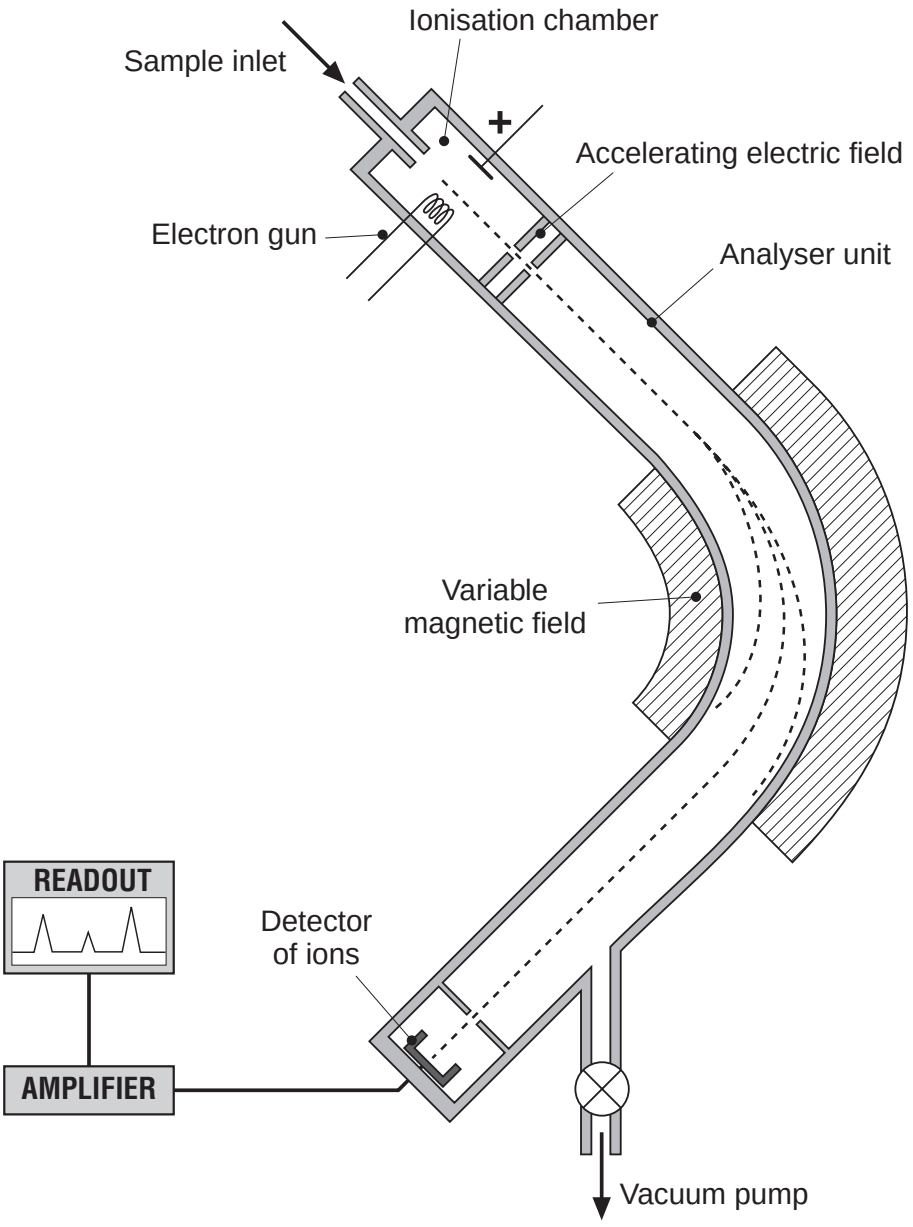


Fig. 2

SYLLABUS SECTION 7.5

Instrument: Mass spectrometer

Ordinary level

In a mass spectrometer, molecules are broken into fragments with different masses. These are separated and the relative amounts recorded, giving the mass spectrum of the molecule. Different molecules have different mass spectra. Mass spectrometry can therefore be used to analyse materials such as gases from a waste dump and to trace organic pollutants in water.

(Note that the interpretation of mass spectra is not required.)

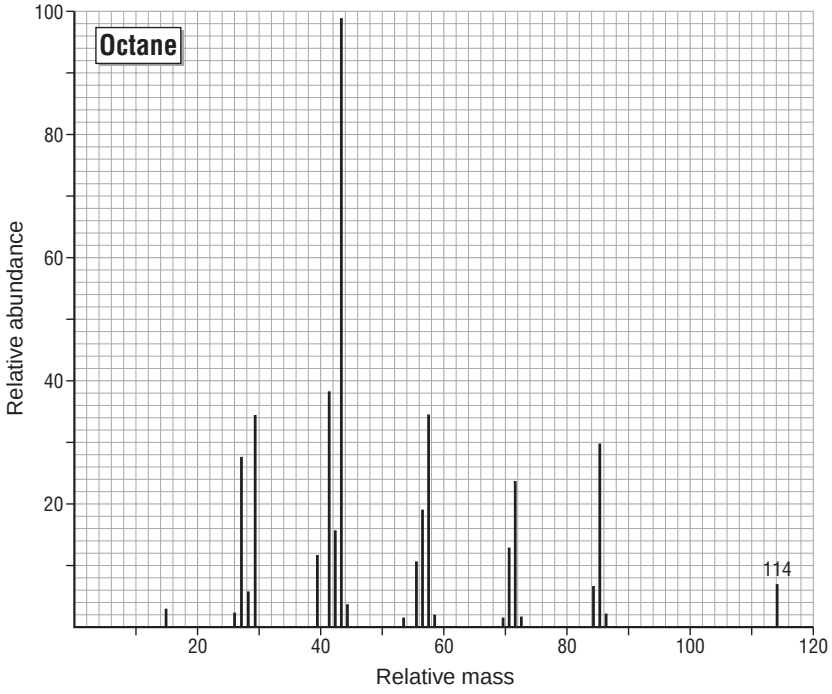


Fig. 3(i)

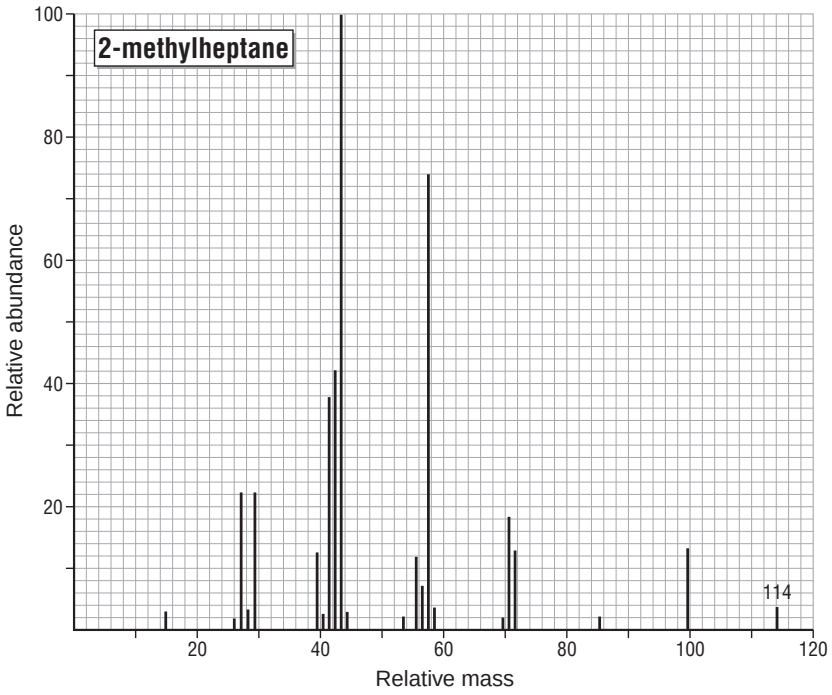


Fig. 3(ii)

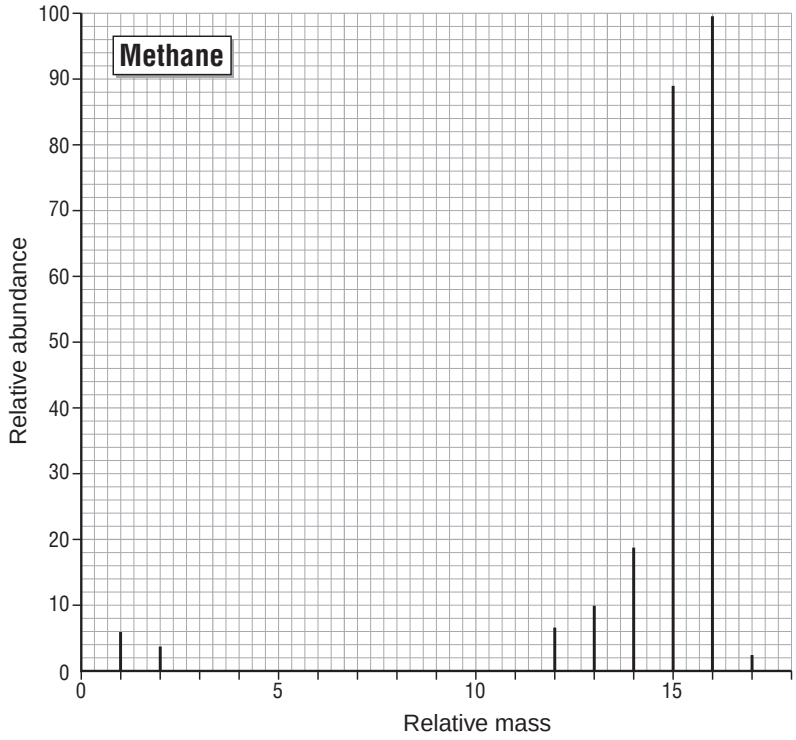


Fig. 4(i)

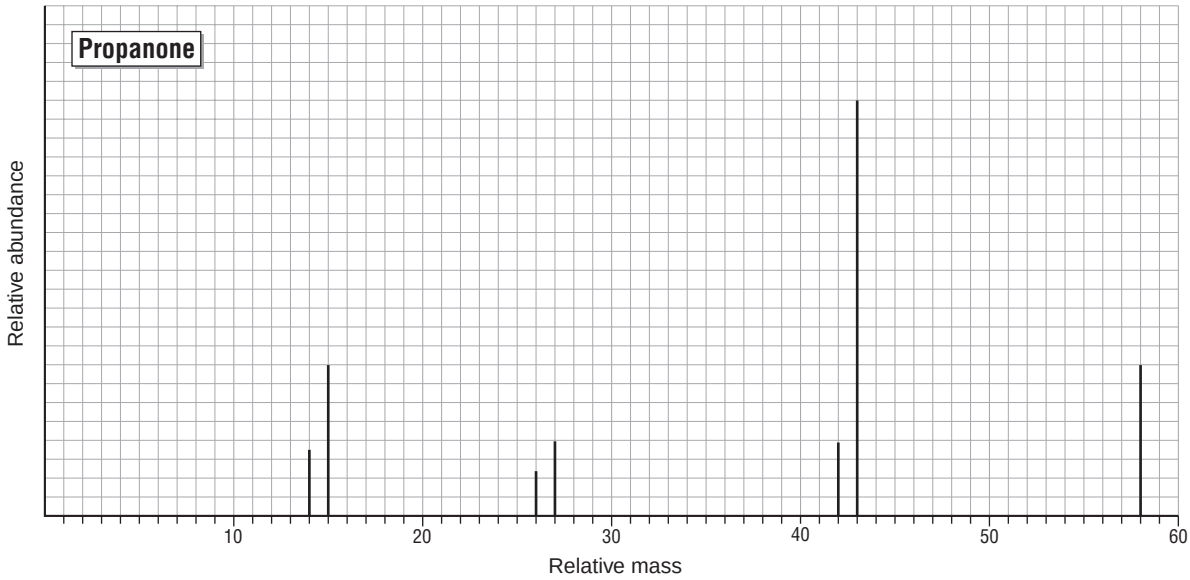


Fig. 4(ii)

SYLLABUS SECTION 1.4

Instrument: Atomic absorption spectrometer

Higher level

The amount of an element in a sample can be estimated from the absorption of radiation by free atoms of that element in an instrument called the atomic absorption spectrometer (fig. 5).

The sample to be analysed is dissolved and introduced into the instrument as a fine spray. It is converted in a flame into atoms of the element to be analysed. A special lamp, whose cathode contains the element of interest, generates light characteristic of the element. This light is passed through the atomised sample and is absorbed by it. The amount of light absorbed depends on the amount of the element present.

Atomic absorption spectrometry (AAS) is particularly useful for the analysis of trace metals. It has many applications, for example the analysis of lead in the blood of workers in lead mines.

SYLLABUS SECTION 9.4

Instrument: Atomic absorption spectrometer

Higher level
An atomic absorption spectrometer (see syllabus section 1.4) is used to analyse heavy metals, such as lead and cadmium, in water.

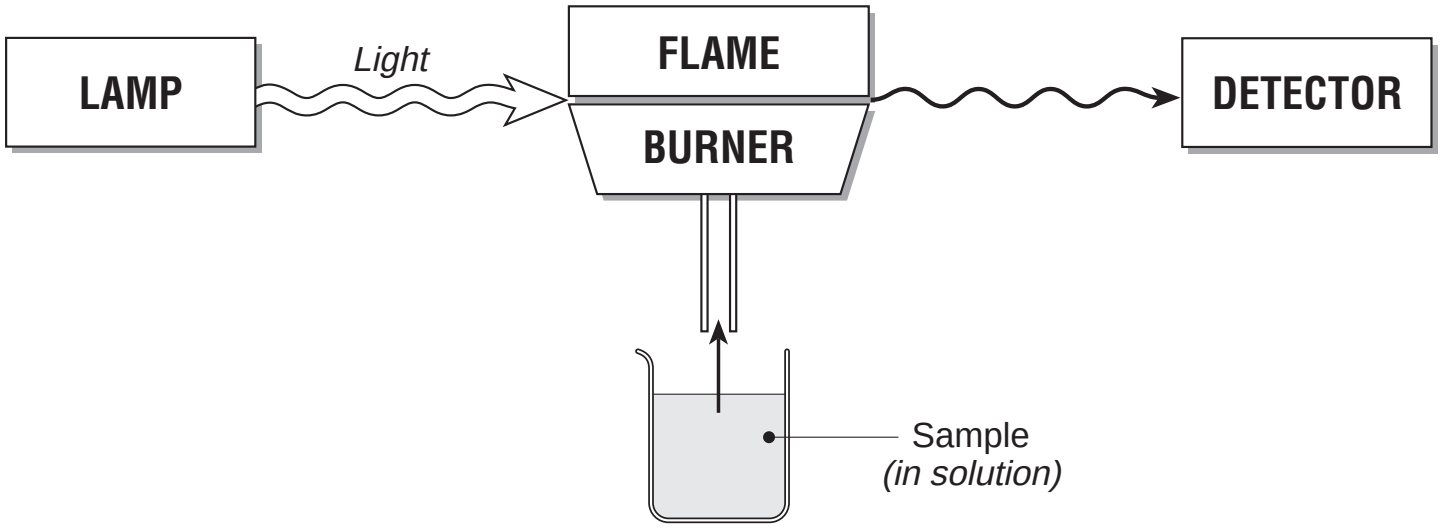


Fig. 5

SYLLABUS SECTION 7.5

Technique: chromatography

Ordinary level

Chromatography is the term used to describe a separation technique in which a mobile phase carrying a mixture is caused to move in contact with a selectively absorbent stationary phase. There are a number of different kinds of chromatography, which differ in the mobile phase and stationary phase used.

In paper chromatography the mobile phase is a solvent and the stationary phase is water held in the fibres of chromatography paper. In column chromatography the mobile phase is again a solvent and the stationary phase is a finely divided solid, such as silica gel or alumina. In thin- layer chromatography the mobile phase is also a solvent and the stationary phase is a thin layer of a finely divided solid, such as silica gel or alumina, supported on glass or aluminium.

Solid-phase extraction devices are inexpensive forms of column chromatography that allow for particularly fast separations of materials.

Thin-layer chromatography is particularly useful in forensic work, for example in the separation of dyes from fibres.

Gas chromatography and high-performance liquid chromatography are more advanced chromatographic techniques.

SYLLABUS SECTION 7.5

Technique: gas chromatography

Ordinary level

In gas chromatography (figs. 6(i) and 6(ii)), the mobile phase is a gas and the stationary phase is a non-volatile liquid (which is coated on fine particles of an inert solid). Gas chromatography has many applications, for example drug tests on athletes and blood alcohol tests. In analytical work a gas chromatograph is sometimes coupled with a mass spectrometer. The gas chromatograph separates the different components of the mixture being analysed, and each component is then separately analysed by the mass spectrometer.

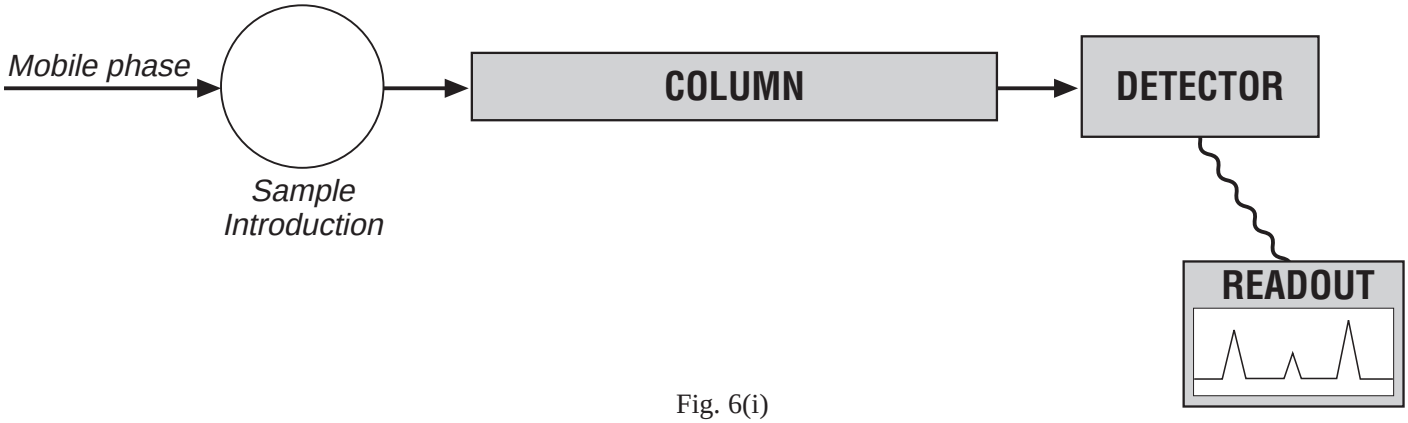


Fig. 6(i)

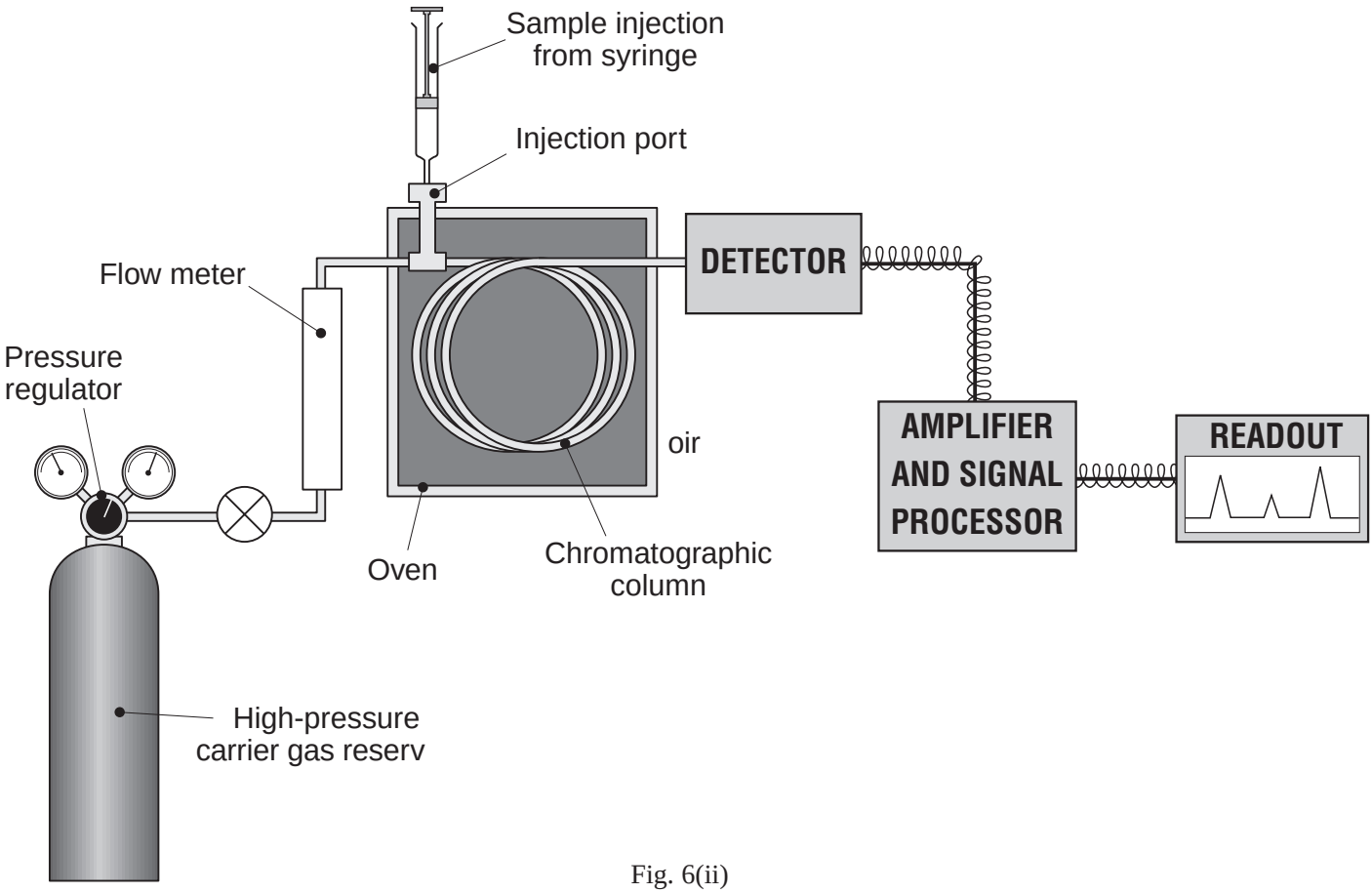


Fig. 6(ii)

SYLLABUS SECTION 7.5

Technique: High-performance liquid chromatography (HPLC)

Ordinary level

In high-performance liquid chromatography (fig. 7) the mobile phase is a solvent and the stationary phase is very fine particles of silica. High pressure has to be applied to the solvent to force it through the column. HPLC is used in the separation of mixtures that are less volatile than those amenable to separation by gas chromatography. HPLC has many applications, for example analysis of growth promoters in meat and of vitamins in foods.

Fig. 8 shows a HPLC chromatogram of a mixture of compounds.

In HPLC, detection is usually by means of an ultraviolet absorption spectrometer, but, as in gas chromatography, a mass spectrometer is sometimes used. The mixture is separated by HPLC, and each component can then be individually analysed.

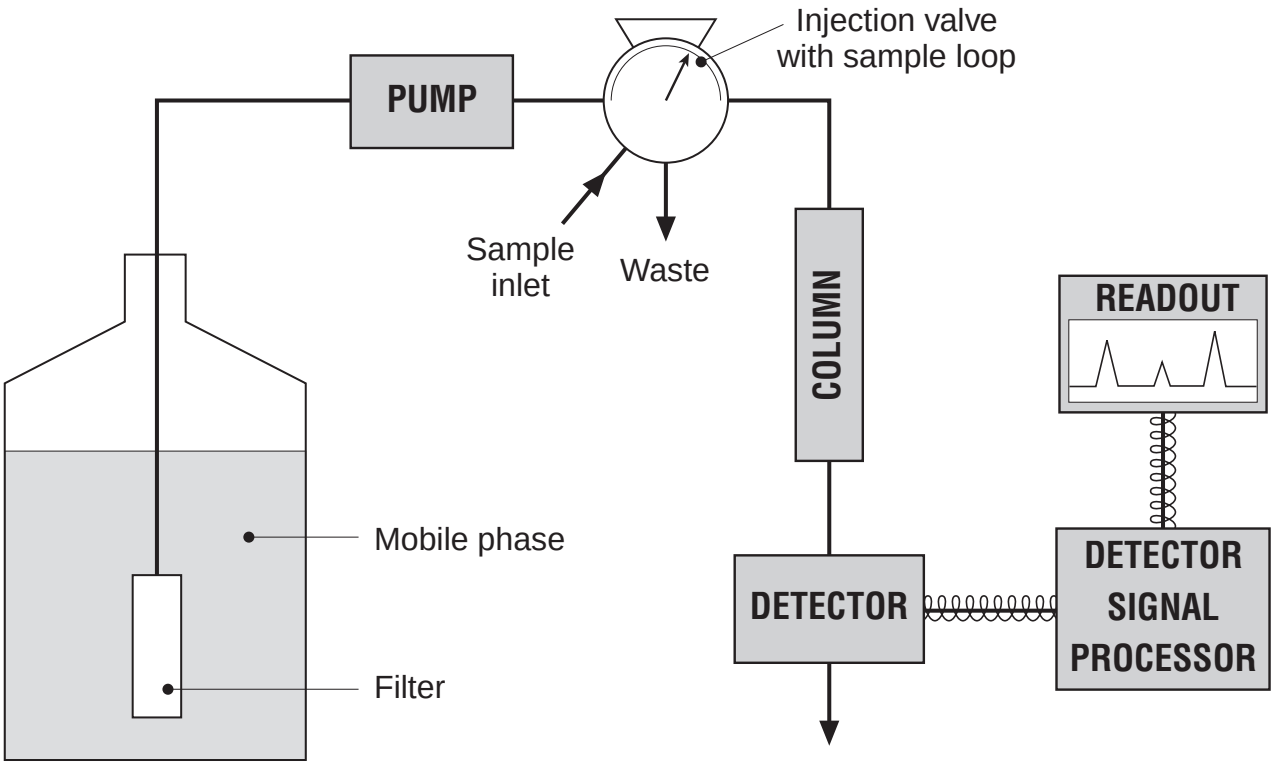


Fig. 7

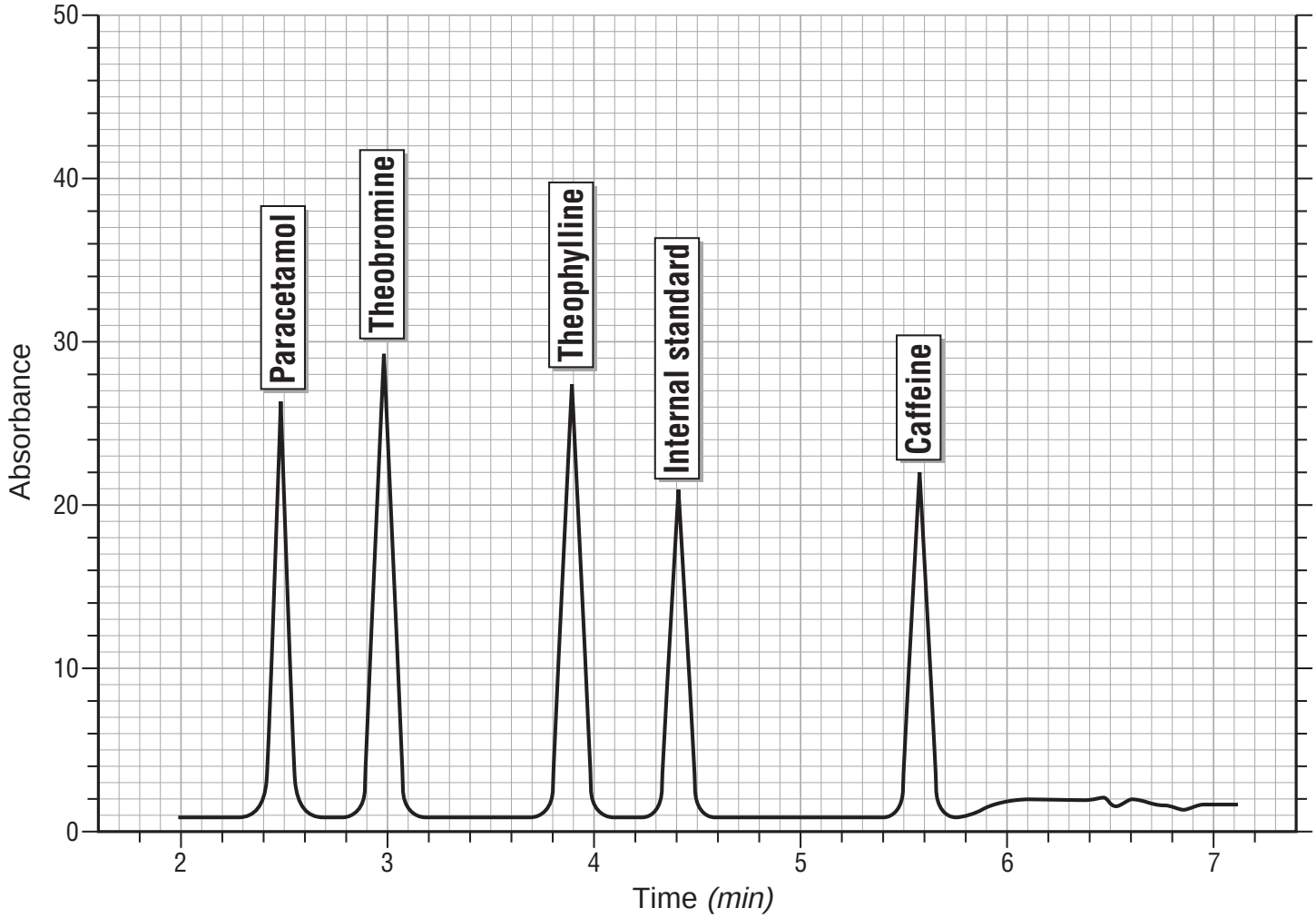

Absorbance
50
40
30
20
10
0
Paracetamol
Theobromine
Theophylline
Internal standard
Caffeine
2
3
4
5
6
7
Time (min)

Fig. 8

SYLLABUS SECTION 7.5

Technique: Infrared absorption spectrometry (IR)

Higher level

Infrared absorption spectrometry is a technique involving the absorption of infrared radiation. It is a "fingerprinting" technique, as each compound has its own almost unique infrared spectrum. For this reason, IR is particularly useful in the identification of substances, for example plastics and drugs. The infrared spectra of methanol and methanoic acid are shown in fig. 9 (i) and fig. 9 (ii), respectively.

(Note that the interpretation of spectra is not required.)

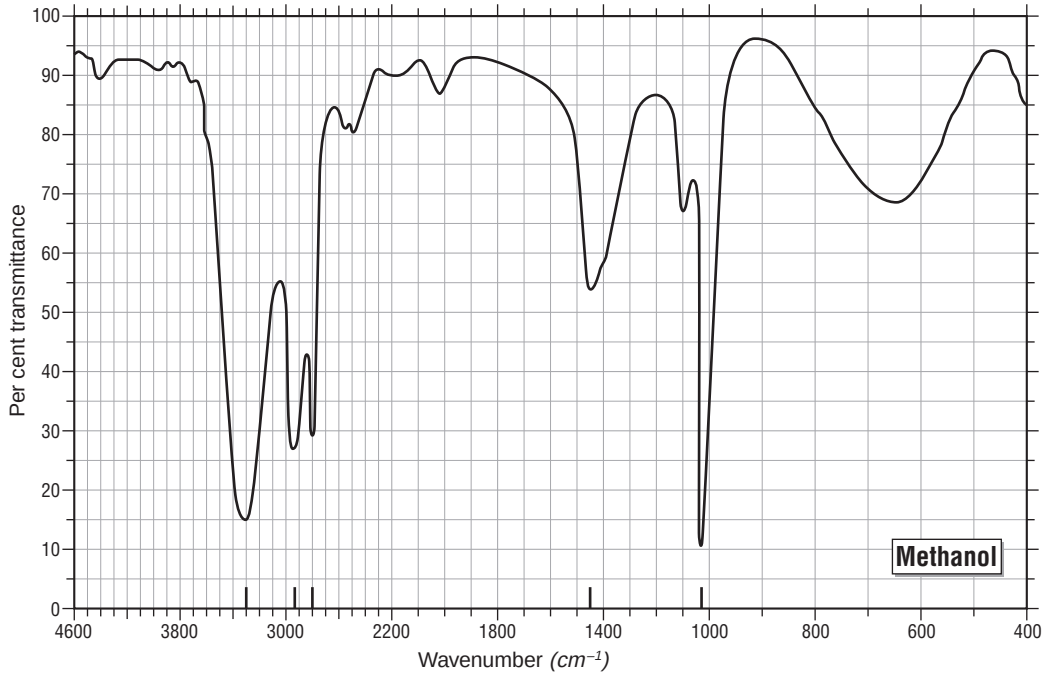


Fig. 9(i)

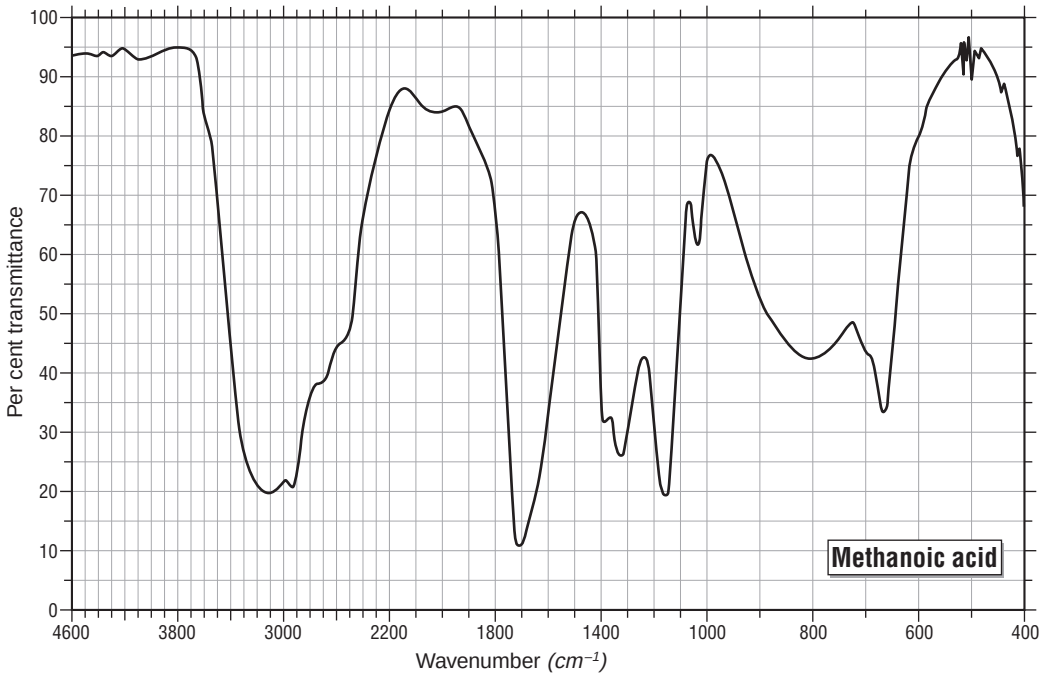


Fig. 9(ii)

SYLLABUS SECTION 7.5

Technique: Ultraviolet absorption spectrometry (uv)

Higher level

Ultraviolet absorption spectrometry is a technique involving the absorption of ultraviolet radiation. This is a quantitative technique and is used in the quantitative determination of organic compounds, for example drug metabolites and plant pigments. Fig. 10 shows the ultraviolet spectrum of benzene.

(Note that the interpretation of spectra is not required.)

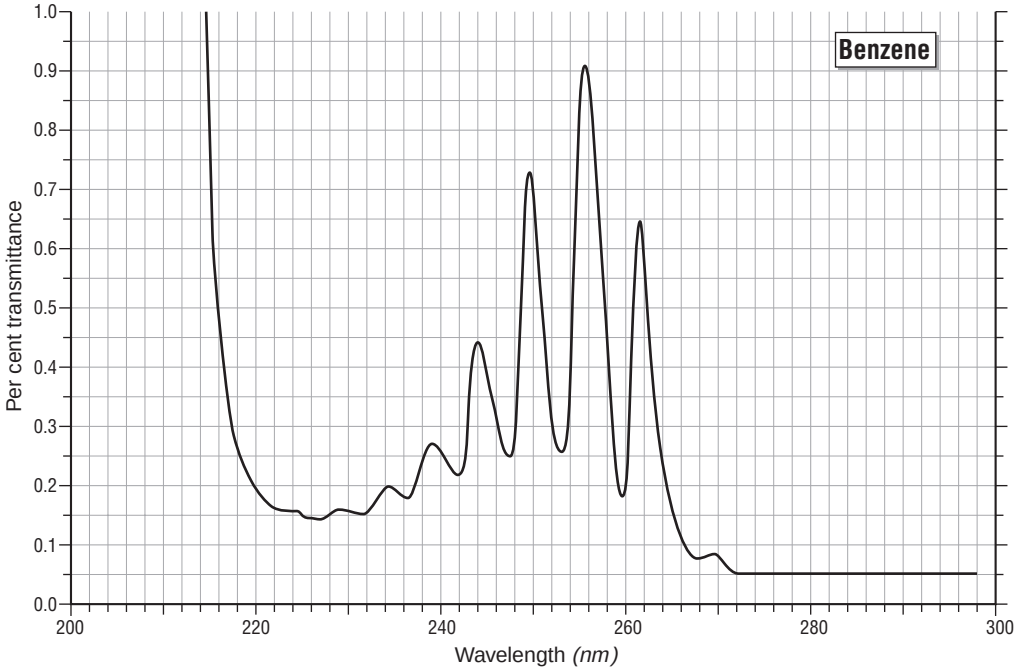


Fig. 10

SYLLABUS SECTION 9.4

Technique: colorimetry

Ordinary level

Colorimetry is a technique involving the comparison of the colour of a solution with that of a range of standard solutions. There is a linear relationship between concentration and absorbance of light of a specific wavelength. Calorimetry is therefore a quantitative technique, and examples of its use include the analysis of lead in water and of fertilisers. A simplified diagram of a colorimeter is shown in Fig. 11.

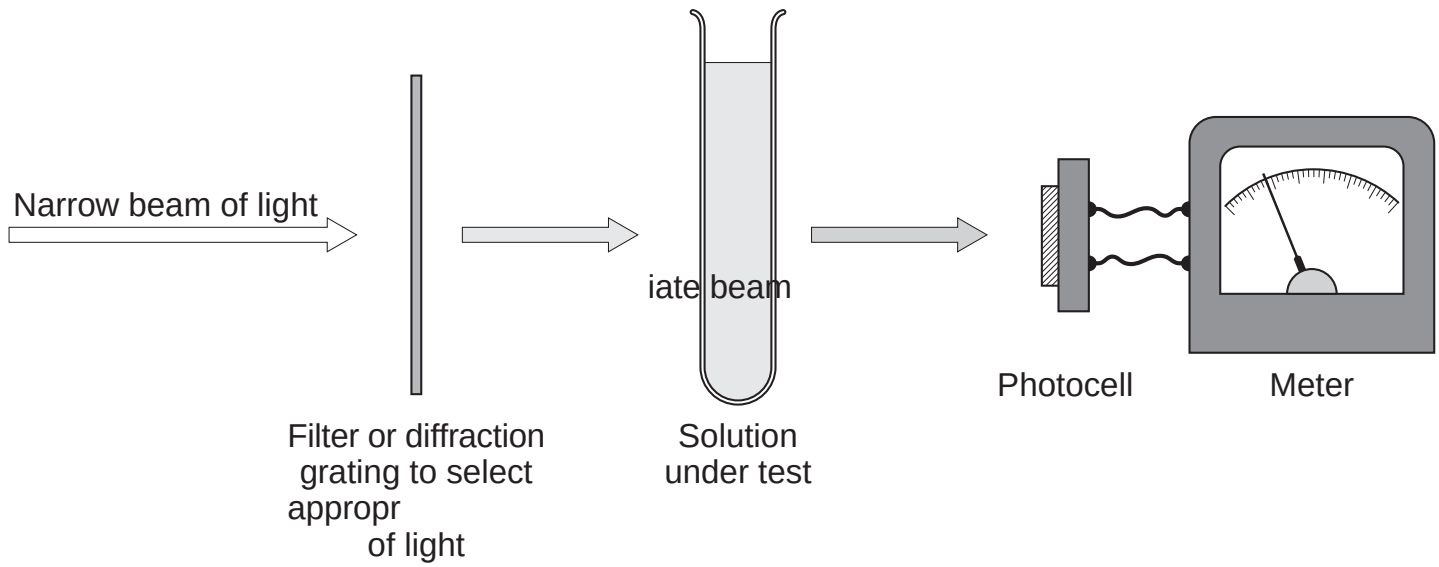


Fig. 11

SYLLABUS SECTION 9.4

instrument: pH meter

Ordinary level

A pH meter (Fig. 12) consists of a glass electrode half-cell, a reference half-cell (both usually contained in the same housing), and a sensitive meter which measures voltage. The electrode potential of the glass electrode depends on the concentration of H^+ ions in the solution in which the electrode is placed. The voltmeter is designed to read the pH of the solution directly, rather than the voltage.

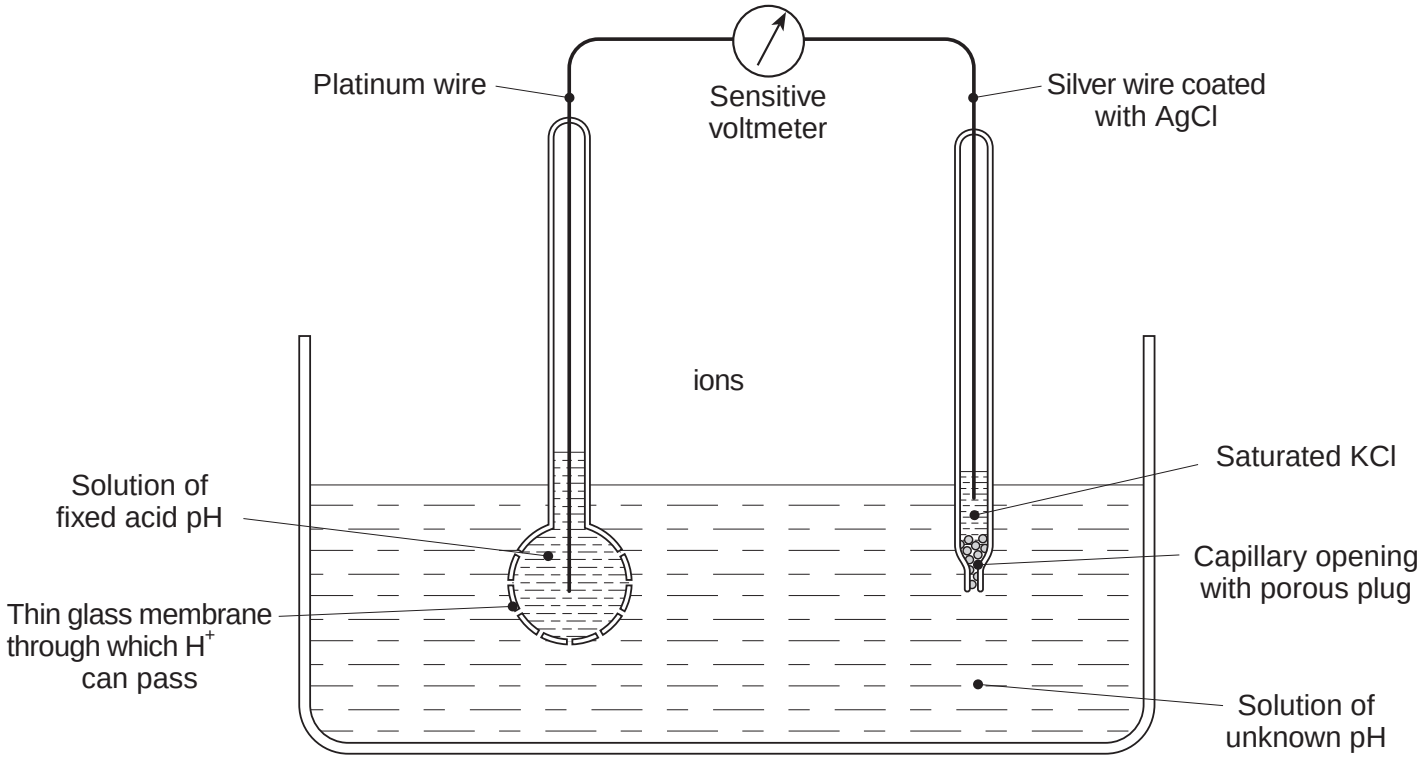


Fig. 12

SYLLABUS SECTION OPTION 2A.1

Technique: x-ray Crystallography

Ordinary level

The structure of crystals may be determined by analysing the way X-rays are scattered by the crystal (fig. 13). This technique was developed by William H. Bragg and his son, William L. Bragg, and has been used to determine the structure of many crystals. Dorothy Hodgkin used this technique to determine the structures of vitamin B_{12} and penicillin.

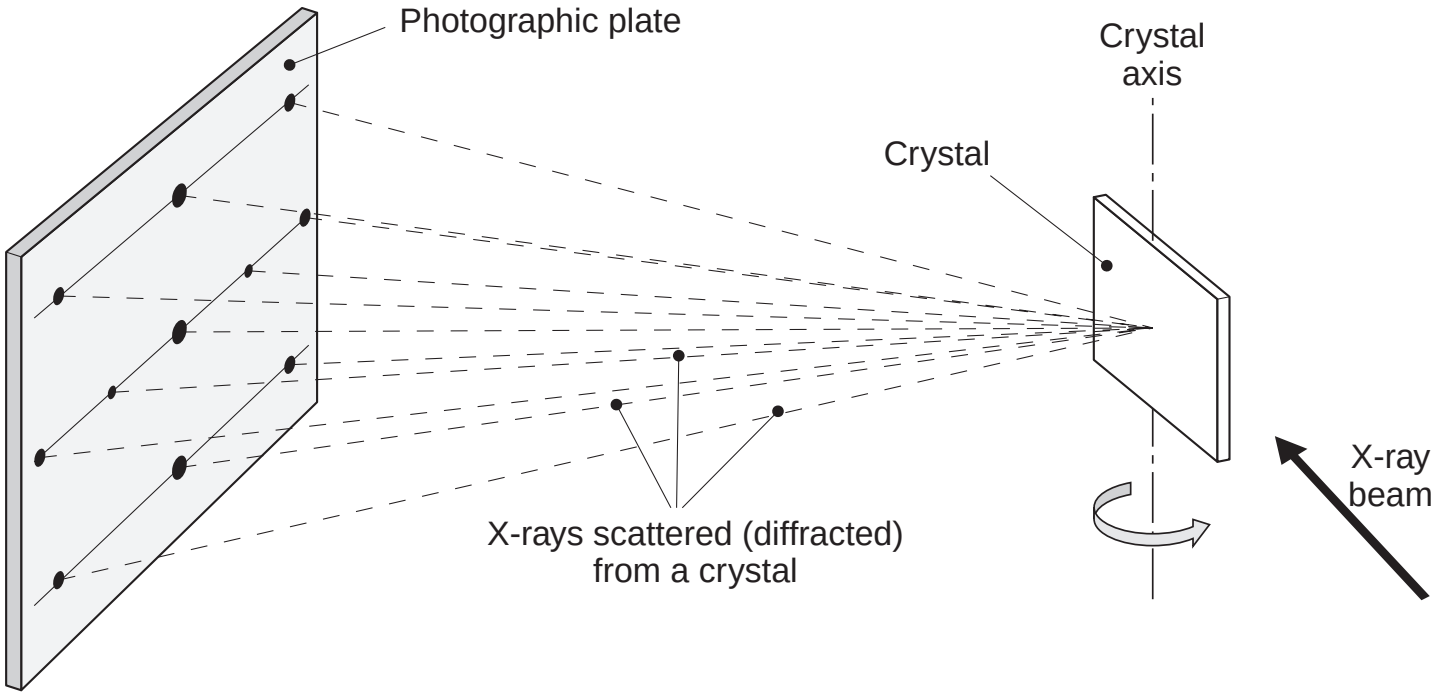
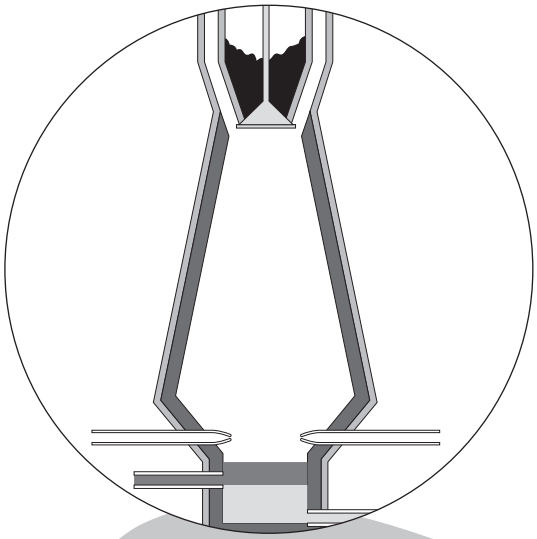


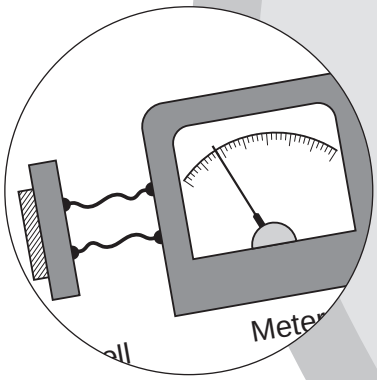
Fig. 13.

X-rays scattered from a crystal produce a pattern of dots on a photographic plate.
(In modern instruments the scattered beams are detected electronically.)

Section four

Industrial Chemistry (General Principles) and Industrial Visits





4.1 INTRODUCTION

It is recommended that students taking option 1A should visit a local chemical industry. The industrial visit should involve consideration of each of the following, as far as they are relevant to the industrial process concerned:

- feedstock
- rate
- product yield
- co-products
- waste disposal and effluent control
- quality control
- safety
- costs
- site location
- suitable materials for the construction of a chemical plant
- type of process
- uses of products
- skills and expertise of work force

(I) FEEDSTOCK

The reactants in an industrial process are called the feedstock. Feedstock is produced from the raw materials. In the industry visited, the raw materials should be identified, and the purification or chemical treatment of the raw materials should be studied.

(II) RATE

The temperature, pressure and catalyst for the process should be noted, and the way in which each of these contributes to a satisfactory rate should be understood.

(III) YIELD

The conditions chosen must be such as to result in a satisfactory yield. How the temperature, pressure and catalyst for the process each contribute to a satisfactory yield should be understood. If the reaction is reversible and the required reaction is exothermic, the conditions that give rise to a high yield may greatly reduce the rate, and vice versa. This leads to a compromise in choosing the reaction conditions.

(IV) CO-PRODUCTS

Any co-products formed in the process should be noted, and the separation of these from the main product, and their disposal (or sale), should be studied.

(V) WASTE DISPOSAL AND EFFLUENT TREATMENT

The methods used to dispose of any solid and gaseous waste produced in the process should be studied, as well as the methods of effluent treatment.

(VI) QUALITY CONTROL

The methods of quality control used should be studied only to the extent that they relate to the instrumentation referred to elsewhere in the syllabus (see data on instrumentation in section 3).

(VII) SAFETY

The site and layout of the plant should be studied with regard to safety considerations. Safety features incorporated in the plant, on-site training of the staff and the monitoring of hazards should also be noted.

(VIII) COSTS

Fixed costs are those that have to be paid regardless of the rate of production. These include labour costs, plant depreciation, land rental and repayments on loans. Variable costs are those that depend directly on the level of plant output. These include the cost of heat, electricity and the raw materials.

The fixed costs and variable costs pertaining to the process studied should be noted (qualitatively), as well as the costs of waste disposal. Methods that are used to reduce costs should also be studied. These include some or all of the following: use of heat exchangers, use of catalysts, recycling of feedstock and selling of useful co-products.

(IX) SITE LOCATION

Chemical industries are often established near the source of the raw materials or near a market for the product. The local availability of water can also be important. The availability of a suitable work force, and of transport for raw materials and products, are also important considerations. For the process being studied, the reasons for the location of the plant at that particular site should be determined.

(X) SUITABLE MATERIALS FOR THE CONSTRUCTION OF A CHEMICAL PLANT

Plant construction materials must not react with the feedstocks, solvents, catalysts or products involved in the process. The construction materials should therefore be unreactive and resistant to corrosion by the chemicals with which they come in contact. The materials used in the construction of the plant for the process being studied should be noted, and in particular the materials used to construct the reaction vessels.

(XI) TYPE OF PROCESS

Students should note whether a batch process, a semi-continuous process or a continuous process is involved.

(XII) USES OF PRODUCTS

The uses of the products should be noted.

(XIII) SKILLS AND EXPERTISE OF WORK FORCE

Employees who are directly responsible for the operation of a chemical plant, such as chemical engineers, chemists and process operators, need to be well qualified and well trained. Students should find out what educational qualifications are needed by different types of employees in the plant and why they are needed. Other types of employees may include accountants, clerical workers, computer programmers, mechanical engineers, biochemists, biologists, physicists, fitters, cleaners, caterers, laboratory technicians, construction workers, transport workers and others.

4.2 INDUSTRIAL VISITS

It is not necessary that the industry visited be one of the syllabus case study industries. Whatever industry is visited, however, the factors discussed above should be kept in mind to the extent that they are relevant to the process concerned.

An industrial visit

(i) gives students an opportunity to experience industrial chemistry at first hand

(ii) illustrates parts of the syllabus (especially option 1A.1)

(iii) helps students to see the relevance of chemistry.

4.2.1 PREPARATION FOR THE VISIT

To find a suitable chemical plant to visit, and the appropriate contact person, consult *The Chemical Industry in Ireland: A Directory for Teachers*, published by the Schools Information Centre on the Irish Chemical Industry. If the school is in an area where there is no chemical plant, certain other processes that involve some of the factors to be studied could be considered. These include food-processing plants, breweries, dairies, bakeries and water treatment works.

Contact with the firm involved should be made well in advance of the proposed visit. The firm will need to agree and have an understanding of

- when the visit will take place
- how long it will take (a maximum of two hours is recommended)
- how many students are involved
- how old the students are
- the level of the students' background knowledge
- the context of the visit in relation to the syllabus.

Unless the teacher has previously visited the plant, it is recommended that a preliminary visit be made by him or her. In any case, the teacher needs to know in outline what goes on at the plant, in order to prepare the students for the visit. Students should have studied option 1A.1 in advance of the visit and should be given a brief description of the process. They should be encouraged to ask questions during the visit. They could be given a list of suggested questions, such as those in section 4.3. Individual students or pairs of students could be allocated particular questions to ensure that all the information is obtained.

4.2.2 DURING AND AFTER THE VISIT

For the tour around the plant, the students may have to be split into groups. They should be encouraged to ask questions not only of the guides but of other personnel in the plant. The visit should be followed up at school. Students could write reports, and should certainly complete answers to a list of questions.

4.3 VISITING A CHEMICAL PLANT

Possible questions

(I) FEEDSTOCK

What are the main raw materials used in the plant?

Why are these particular raw materials used?

How are the raw materials converted into suitable feedstock?

(II) RATE

What conditions of temperature and pressure are used in the reaction or reactions?

What catalyst, if any, is used?

(III) PRODUCT YIELD

Does the choice of reaction conditions represent a compromise between rate and yield?

(IV) CO-PRODUCTS

What are the main co-products?

How are they separated?

What happens to these co-products?

(V) WASTE DISPOSAL AND EFFLUENT CONTROL

What environmental problems are associated with the process?

What emission control procedures are used?

(VI) QUALITY CONTROL

What quality control procedures are used?

(VII) SAFETY

Are any hazards involved in operating the process?

How are they monitored?

What safety features and on-site training are used?

(VIII) COSTS

What are the main fixed costs?

What are the main variable costs?

(IX) RECYCLING OF MATERIALS AND ENERGY

Is any material recycled?

If so, how?

Is any heat energy recycled?

If so, how?

(X) SITE LOCATION

Why is the plant located at this site?

(XI) PLANT CONSTRUCTION MATERIALS

What chemical factors affect the choice of materials used in the construction of the plant?

(XII) TYPE OF PROCESS

Is the type of process used a continuous, semi-continuous or batch process?

(XIII) USES OF PRODUCTS

What are the products?

What are they used for?

(XIV) SKILLS AND EXPERTISE OF WORK FORCE

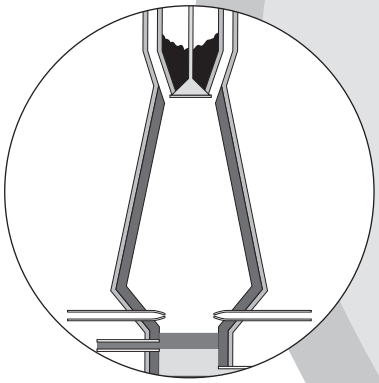
Name four types of employee in the plant.

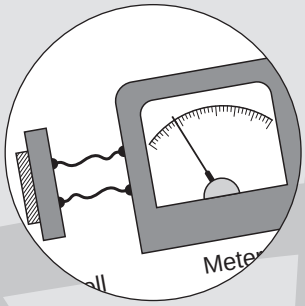
In each case, suggest why they are needed.

In each case, state what educational qualifications they need.

Section five

Practical Work and Safety





PRACTICAL WORK AND SAFETY

5.1 PRACTICAL WORK

In this syllabus the term "practical work" covers all teachers demonstrations and students' experiments that take place in a school science laboratory. This can occur only in a properly organised and safely run laboratory.

5.2 THE SYLLABUS AND PRACTICAL WORK

The syllabus specifies a number of teacher demonstrations and mandatory student experiments. It is recommended that other practical work should also be used in the teaching of chemistry. Additional teacher demonstrations and simple student experiments are important in that they give students an understanding of the chemical concepts and motivate them to learn the subject. The recording of such additional experiments is at the teacher's discretion.

5.3 STUDENTS' PRACTICAL WORK

The student experiments are important in that they develop practical skills, for example setting up and manipulating apparatus and making measurements and observations. The required experiments are listed at the end of the appropriate section of the syllabus. The experiments must be recorded by the students.

5.4 ERRORS AND THEIR TREATMENT IN STUDENTS' PRACTICAL WORK

The students are required to have an appreciation of the errors inherent in practical work and the precautions that should be taken to reduce such errors. No quantitative treatment of errors is required. Students should appreciate that a measurement has a certain level of error, and they should be aware of sources of error in all the mandatory quantitative experiments.

5.5 LABORATORY ORGANISATION AND MAINTENANCE

The syllabus requires that students have access to a laboratory. This should make it possible for the experiments required by the syllabus and any other practical work to be carried out in a safe manner.

A catalogue of the available equipment and chemicals is an important part of the chemistry laboratory. Much of the equipment can be used in a number of ways, although there are items of equipment that illustrate specific syllabus concepts. Necessary precautions should be taken in storing these chemicals. These are outlined in the Department of Education and Science's publication *Safety in School Science.*

When chemicals are being purchased, suppliers are obliged, on request, to supply material safety data sheets (MSDS). There are various web sites that contain a variety of these sheets in English. One such web site is referred to in section 2.5.

5.6 CHEMICALS AND EQUIPMENT

Nearly all the chemicals and equipment listed in appendixes 2 and 3 are at present being used in schools that offer Leaving Certificate Chemistry. Many are also used for Junior Certificate Science practical work, or for practical work in Leaving Certificate Physics or Biology. Appendix 2 lists the chemicals needed for the mandatory experiments, the teacher demonstrations specified in the syllabus, and other experimental work to illustrate parts of the syllabus. A number of the chemicals used for the latter purpose are specifically mentioned in the syllabus. Appendix 3 lists the equipment required for mandatory experiments, specified demonstrations, and other experimental work.

5.7 SAFETY

The general principles of safe laboratory working procedures apply to Leaving Certificate Chemistry. The school safety statement should outline the hazards involved. A basic set of safety rules should be drawn up within the school and displayed in each laboratory and a copy given to each student every year. Appropriate protective clothing and equipment should be available and should be used as necessary. Procedures for the disposal of broken glassware, waste chemicals and solvents should be adequate and safe. For safety reasons, it is strongly recommended that chemicals with short shelf-life be purchased in the smallest amounts possible.

The resources and fittings in a chemistry laboratory should be such as to take into account hazards associated with gas, electricity and water, as well as those associated with the storage, handling, use and disposal of chemicals. Isolation switches for electric power and isolation valves for gas should be provided. A first aid kit, an eye wash kit and washing facilities (i.e., hot water, soap and towels) should be provided. Students should be aware of the correct procedures in the event of a fire or any other hazard. Appropriately located fire extinguishers, fire blankets, sand buckets and absorbent material for dealing with spills should also be provided.

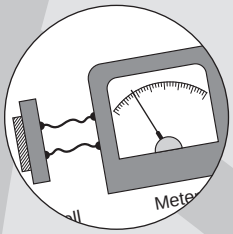
Certain experiments and demonstrations require greater care, for example mandatory experiment no. 7.5 (the preparation and properties of ethanoic acid) and the demonstration of the reaction of potassium with water. The detailed safety precautions required for particular experiments and teacher demonstrations is beyond the scope of this document, but teachers should ensure that they have a clear understanding of the safety issues concerned. A list of useful references is included below.

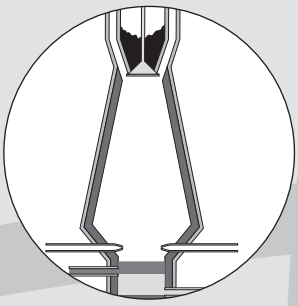
5.8 REFERENCES

CLEAPSS School Science Service
Hazcards (available from CLEAPSS School Science Service, Brunel University, Uxbridge UB8 3PH, England)

CLEAPSS School Science Service
Laboratory Handbook

Appendices





APPENDIX 1

DETAILED LIST OF ADDITIONS AND DELETIONS

This appendix provides a detailed list of additions and deletions compared with the former (1983) Leaving Certificate Chemistry syllabus.

Completely new syllabus subsections are denoted by*. Underlined material refers to the Higher level syllabus only. The numbering, in this section refers directly to the syllabus, for example 1.1, 2.1, etc.

SECTION 1: PERIODIC TABLE AND ATOMIC STRUCTURE

1.1 Periodic Table

Added: History of the idea of elements.

1.2 Atomic Structure

Added: Outline of the historical development of atomic theory.

Fundamental processes that occur in a mass spectrometer.

1.3 *Radioactivity

1.4 Electronic Structure of Atoms

Added: Organisation of particles in atoms 1-20 (numbers of electrons in each main energy level). Social and applied aspects.

Deleted: Electronic configurations of ions of d-block metals.

Deleted from Ordinary level only:
Emission spectra.
Evidence for energy levels.
Energy sub-levels.
Atomic orbitals.
Electronic configurations (s, p, etc.) of atoms and ions.
Ionisation energy.

1.5 Oxidation and Reduction

Added: Electrolysis of aqueous potassium iodide solution. Displacement reactions of metals-experiment. Social and applied aspects.

Deleted: Electrolysis of aqueous copper sulfate using inert electrodes. Faraday's laws.

SECTION 2: CHEMICAL BONDING

Deleted: General properties of typical chlorides and oxides.

2.1 Chemical Compounds

Added: Social and applied aspects.

2.2 Ionic Bonding

Added: Social and applied aspects. Test for phosphate ion.

Deleted: Tests for bromide, iodide and thiosulfate ions.

Deleted from Ordinary level only:
Tests for sulfite and hydrogencarbonate ions.

2.3 Covalent Bonding

Added: Distinction between sigma and pi bonding.

Social and applied aspects.

Polarity test for liquids.

2.5 Shapes of Molecules and Intermolecular Forces

Deleted: Shapes of molecules with pi bonds.

Deleted from Ordinary level only:
Intermolecular forces.
Electron pair repulsion theory.

2.6 Oxidation Numbers

Added: Social and applied aspects.

Deleted from Ordinary level only:
Oxidation numbers.

SECTION 3: STOICHIOMETRY, FORMULAS AND EQUATIONS

3.1 Particulate Nature of Matter

Deleted: Bromine diffusion experiment.

Oil film experiment.

Brownian movement.

3.2 Gas Laws

Added: Boyle's law.

Charles's law.

Social and applied aspects.

Deleted: Law of combining volumes experiment.

Dalton's law.

Graham's law.

Deleted from Ordinary level only:
Kinetic theory of gases.
$PV = nRT$.
Gay-Lussac's law of combining volumes.
Avogadro's law.

3.3 The Mole

Added: Social and applied aspects.

3.4 Chemical Formulas

Deleted: Formula determination experiment.

Deleted from Ordinary level only:
Calculation of empirical formulas, given the masses of reactants and products.

3.5 Chemical Equations

Added: Calculations involving excess of one reactant.

Deleted fromOrdinary level only:
Percentage yields.

SECTION 4: VOLUMETRIC ANALYSIS

4.1 Concentration of Solutions

Added: Calculation of effect of dilution on concentration.

Social and applied aspects.

Deleted from Ordinary level only:
Concentrations in % (w/v) and % (w/w)
Calculations involving % (w/v) % (v/v) and % (w/w).

4.2 Acids and Bases

Added: Social and applied aspects.

Deleted from Ordinary level only:
Brönsted-Lowry theory.

4.3 Volumetric Analysis

Added: Determination of the concentration of ethanoic acid in vinegar.

Determination of iron in an iron tablet.

Experiment to determine the amount of water of crystallisation in a compound.

Experiment to determine the percentage (w/v) of hypochlorite in bleach.

Added to Ordinary level only:
Use of a hydrochloric acid and sodium hydroxide titration to prepare a salt - experiment.

Deleted: Permanganate and ethanedioate titrations.

Back titrations.

SECTION 5: FUELS AND HEATS OF REACTION

5.1 Sources of Hydrocarbons

Added: Hazards of methane production.

Methane as a contributor to the greenhouse effect.

5.2 Structure of Aliphatic Hydrocarbons

Deleted: Isomers of hydrocarbons with more than four carbon atoms (except pentane).

5.3 Aromatic hydrocarbons

Added: Structure of ethylbenzene.

5.4 Exothermic and Endothermic Reactions

Deleted: Heat of combustion experiment.

Calculation of empirical formulas from combustion data.

Bond energy calculations.

Kilogram calorific value calculations.

Heat of neutralisation.

Deleted from Ordinary level only: Hess's law.

5.5 Oil Refining and its Products

Added: Composition of natural gas and LPG.

Addition of mercaptans to natural gas.

Petrol and octane numbers.

Deleted: Distillation of crude oil experiment.

Cracking experiment.

5.6 Other Chemical Fuels

Deleted: Addition reactions of alkynes.

SECTION 6: RATES OF REACTION

6.1 Reaction Rates

Added: Monitoring the rate of production of oxygen from hydrogen peroxide, using manganese dioxide as a catalyst - experiment.

6.2 Factors affecting Rates of Reaction

Added: Social and applied aspects.

SECTION 7: ORGANIC CHEMISTRY

7.1 Tetrahedral Carbon

Added: Social and applied aspects.

Deleted: Traditional names for organic compounds.

Deleted from Ordinary level only: Chloroalkanes.

7.2 Planar Carbon

Added: Social and applied aspects.

Deleted: Traditional names for organic compounds.

Deleted from Ordinary level only: Ketones.

7.3 Organic Chemical Reaction Types

Added: Combustion of organic compounds.

Social and applied aspects (most of).

Evidence for reaction mechanisms.

Organic synthesis: principles and examples.

Deleted: Specific reaction conditions for organic chemical reactions.

Dehydrogenation of alcohols.

Chlorination of alcohols.

Breathalyser.

Hydrolysis of chloroalkanes.

Industrial preparation of most organic compounds.

Mechanism of free radical polymerisation.

Oxidation of secondary alcohols.

Acid hydrolysis of esters.

Use of $LiAlH_4$ and $NaBH_4$ to reduce carbonyl compounds.

Condensation reactions of aldehydes and ketones.

Experiment involving Brady' s reagent.

7.4 *Organic Natural Products

7.5 Chromatography and Instrumentation in Organic Chemistry

Added: Instrumental methods of separation and analysis, and their uses.

Social and applied aspects.

SECTION 8: CHEMICAL EQUILIBRIUM

Deleted: K_c determination experiment.

K_p

8.2 Le Chatelier's Principle

Added: Cobalt chloride experiment.

Deleted: Bismuth chloride experiment.

N_2O_4/NO_2 experiments.

SECTION 9: ENVIRONMENTAL CHEMISTRY: WATER

It is strongly recommended that students visit a water treatment plant, industrial or municipal.

9.1 pH Scale

Deleted from Ordinary level only:
Choice of indicator.
K_w

9.2 Hardness in Water

Added: Tests on scale deposits in a kettle.

9.3 Water Treatment

Added: <u>Pollution by heavy metal ions, and their removal by precipitation.</u>

Social and applied aspects.

9.4 Water Analysis

Added: Instrumental methods of analysis and their uses.

Colorimetric experiment.

Option 1A: ***Additional Industrial Chemistry***

It is strongly recommended that students visit a local chemical industry, and that this visit be a structured one.

Deleted: Properties of nitric acid, nitrates, sulfites and sulfuric acid. Experiment to determine ammonia in a fertiliser.

Industrial manufacture of sulfuric acid.

1A.1 * Principles of Industrial Chemistry

1A.2 * Case Studies

Option 1B: Atmospheric Chemistry

1B.1 Oxygen

Added: Social and applied aspects.

1B.2 Nitrogen

Added: Social and applied aspects.

1B.3 Carbon Dioxide

Added: The greenhouse effect (detailed treatment).

Other social and applied aspects.

Demonstration.

Deleted from Ordinary level only:
Carbon dioxide in water.

1B.4 Atmospheric Pollution

Added: Demonstration.

Scrubbing of waste gases.

1B.5 *The Ozone Layer

Option 2A: Materials (Crystals, Addition Polymers, Metals)

2A.1 Crystals

Added: Metallic crystals.

Social and applied aspects.

2A.2 Addition Polymers

Added: Historical aspects.

Recycling.

Poly(propene).

Demonstration.

Deleted: Polyesters.

Poly(propenonitrile).

Preparation of poly(phenylethene) experiment.

Option 2B: Additional Electrochemistry and the Extraction of Metals

Deleted: Fuel cells.

2B. 1 The Electrochemical Series

Added: Historical aspects.

Deleted: The effect of heat on metal nitrates, carbonates, and hydroxides. Reactions of metals with air, water and acids.

2B.4 Strongly Electropositive Metals (Na and Al)

Added: Recycling of aluminium.

Deleted: Extraction, occurrence and uses of calcium and magnesium.

2B.5 d-Block Metals

Added: Electric arc process for steel manufacture.

Deleted: Detail on extraction, occurrence and uses of copper and zinc.

APPENDIX 2

The following is a suggested list of chemicals appropriate for Leaving Certificate Chemistry; it is neither prescriptive nor exhaustive. Valid alternatives may be available for some of the chemicals listed.

NAME
Aluminium foil
Aluminium metal sheets (packet)
Aluminium oxide
Aluminium powder
Aluminium sulfate
Ammonia 0.88
Ammonium chloride
Ammonium iron(II) sulfate
Ammonium metavanadate
Ammonium molybdate
Ammonium nitrate
Ammonium phosphate
Ammonium sulfate
Ampoules (box) hydrochloric acid solution
Ampoules (box) potassium manganate(VII) (potassium permanganate) solution
Ampoules (box) sodium hydroxide solution
Ampoules (box) sulfuric acid solution
Anti-bumping granules
Barium chloride
Benzaldehyde
Benzoic acid
Bismuth trichloride
Bleach (liquid)
Bleaching powder
Bromine
Buffer solution, pH 10
Buffer solutions, pH 4, 7
Butan-1-ol

Butanal
Butanoic acid
Butanone
Calcium carbide
Calcium carbonate
Calcium chloride
Calcium granules
Calcium hydroxide
Calcium oxide
Candles
Carbon electrodes (packet)
Citric acid
Cloves
Cobalt chloride
Copper electrodes
Copper turnings
Copper wire (bare 22 swg)
Copper(I) oxide
Copper(II) carbonate
Copper(II) chloride
Copper(II) chromate
Copper(II) oxide
Copper(II) sulfate
Copper(II) sulfate anhydrous
Cyclohexane
Decon 90
Detergent
Dyes, water-soluble, red and blue
EDTA disodium salt
Ethanal (Acetaldehyde)

Ethanedioic acid (oxalic acid)

Ethanoic acid (acetic acid)

Ethanol 95% (industrial methylated spirits)

Ethyl benzoate

Ethyl ethanoate (ethyl acetate)

Fehling's solution no. 1

Fehling's solution no. 2

Glass wool

Glucose, anhydrous

Glycerol

Heptane

Hydrochloric acid

Hydrogen peroxide 100 vol

Indicator paper box (selection)

Iodine

Iron tablets (packet)

Iron(II) sulfate

Iron(III) chloride

Lard

Lauroyl peroxide

Lead bromide

Lead electrodes

Lead ethanoate

Lithium

Lithium chloride

Litmus powder

Lycopodium powder

Magnesium carbonate

Magnesium powder

Magnesium ribbon

Magnesium sulfate

Manganese dioxide

Manganese sulfate dihydrate

Marble chips

Methanal (formaldehyde) solution

Methanoic acid (formic acid) 90%

Methanol

Methyl orange powder

Methylated spirits

Methylbenzene (toluene)

Nitric acid

Octane

Packet of wooden splints

Paraffin (liquid)

Paraffin, light

Pentane

Petroleum ether (40/60)

Petroleum jelly

Phenolphthalein solid

Phenylethene (styrene)

Platinum wire

Poly(chloroethene)

Poly(ethene) (high-density)

Poly(ethene) (low-density)

Poly(phenylethene) (polystyrene)

Poly(propene)

Poly(tetrafluoroethene)

Potassium bromide

Potassium chloride

Potassium chromate

Potassium dichromate, crystalline

Potassium hydroxide

Potassium iodate

Potassium iodide

Potassium manganate(VII) (potassium permanganate)

Potassium metal

Potassium nitrate

Potassium sodium tartrate

Potassium thiocyanate

Propan-1-ol

Propan-2-ol

Propanal (propionaldehyde)

Propanone (acetone)

Silver nitrate

Sodium carbonate, anhydrous

Sodium carbonate, hydrated

Sodium chloride

Sodium dichromate, crystalline

Sodium ethanoate (sodium acetate)

Sodium hydrogencarbonate

Sodium hydroxide

Sodium hypochlorite solution

Sodium metal in paraffin

Sodium sulfate

Sodium sulfite

Sodium thiosulfate

Solochrome black

Sphere polystyrene:packet (100 / 25 mm)

Starch, soluble

Strontium chloride

Sugar

Sulfur, fine powder

Sulfuric acid

Tin plate or foil (25 mm^2)

Trimethylpentane, 2, 2, 4 – (iso-octane)

Universal indicator solution

Urea

Vinegar

Zinc carbonate

Zinc electrodes

Zinc granulated

Zinc powder

APPENDIX 3

The following is a suggested list of equipment for Leaving Certificate Chemistry; it is neither prescriptive nor exhaustive.

Quantities indicated are for a class of 24 students. **Items indicated in bold are essential for the mandatory experiments specified in the syllabus.**

*** = alternative available - indicated elsewhere in the equipment list**

**** = may not be needed if appropriate datalogging equipment is purchased**

Adhesive tape dispenser	1
Adhesive tape in 1" rolls	10
Aluminium melting-point blocks*	**12**
Aspirators, polypropylene, 10 l graduated	10
Balance, electronic, 2 kg, 2 decimal places	**1**
Balance, electronic, 0-400 g, 3 decimal places	1
Barometer (aneroid) accurate to 1 mm of mercury**	**1**
Battery, rechargeable (assorted set of 20)	1
Beakers tongs	**12**
Beakers, 1 l, PPR	12
Beakers, 1 l, Pyrex	**15**
Beakers, 100 ml, Pyrex	**15**
Beakers, 2 l, PPR	6
Beakers, 2 l, Pyrex	6
Beakers, 250 ml, low form, Pyrex	**15**
Beakers, 250 ml, PPR	**12**
Beakers, 400 ml, low form, Pyrex	**15**
Beakers, 400 ml, PPR	12
Beakers, 50 ml, PPR	12
Beakers, 50 ml, Pyrex	**15**
Beehive shelves, 75 mm	**15**
Benchkote (roll), 46 cm × 50 m	1
Boiling tubes, Pyrex, 150 mm × 24	**2**
Bossheads, zinc-plated	**30**
Bottles, dispensing, 250 ml, polystop, graduated to 8 ml	**15**
Bottles, reagent, amber, narrow-mouth, polythene stoppers	**30**
Bottles, reagent, clear, narrow-mouth, polythene stoppers	**10**
Brushes, beaker, wide handle	**15**

Brushes, bottles, 75 × 150, nylon	**12**
Brushes, burette, 19 mm × 75 mm	**10**
Brushes, flask, wings head	**20**
Brushes, T-tube, 30 mm bristle	**15**
Buchner adaptors, rubber	**100**
Buchner flasks, 250 ml	**15**
Bulb-holders, medium, Edison screw, packet of 10	2
Bulbs, medium, Edison screw, 1.5 V, 0.3 A, packet of 10	10
Bungs, red, 15 mm, one hole, for test-tubes	**100**
Bungs, red, 15 mm, solid, for test-tubes	**100**
Bungs, red, 21 mm, one hole, for boiling tubes	**100**
Bungs, red, 21 mm, solid for boiling tubes	100
Bungs, red, 31 mm, one hole, for conical flasks	**30**
Bungs, red, 31 mm, solid, for conical flasks	30
Bungs, red, 31 mm, two hole, for conical flasks	**30**
Bungs, rubber, no. 13, one hole	50
Bunsen burners (flamefast)	**15**
Burette clamps	**12**
Burette storage racks (10 slots)	**2**
Burettes, 50 ml, PTFE stopcock and replaceable tip	**15**
Calorimeters, Cu 75 × 50, lid, stirrer, lagged, outer-vessel,	12
Carbon rods	50
Chart, periodic table (laminated)	**1**
Chromatography paper, boxes, 25 × 25 cm	5
Chromatography paper, rolls, 5 cm × 100 m	**5**
Chromatography tanks	**6**
Clamps, rubber jaw, zinc-plated	**30**
Clock glasses, 10 cm, glass	**15**
Clock glasses, 7.5 cm, glass	15
Clock glasses, polythene, 100 mm	15

Clock glasses, polythene, 80 mm	15
Cloths, cotton (sets of 50)	**1**
Colorimeter**	**1**
Comparators**	**12**
Conical flasks, Pyrex, 250 ml	**15**
Cork borer sets, 1-6 + cork borer sharpener	**2**
Craft knives with 2 packets of blades	2
Crocodile clips	**100**
Crucibles, 25 ml, 40 mm, porcelain with lid	15
Cylinders, graduated, 1 l, clear plastic	**12**
Cylinders, graduated, 10 ml, clear plastic	**12**
Cylinders, graduated, 100 ml, clear plastic	**12**
Cylinders, graduated, 2 l, clear plastic	2
Cylinders, graduated, 25 ml, clear plastic	**12**
Cylinders, graduated, 250 ml, clear plastic	12
Cylinders, graduated, 500 ml, clear plastic	12
Deioniser (water), complete	**1**
Demo metre scales, 0-1 V	1
Demo metre scales, 0-100 °C	1
Demo metre scales, 0-3 V	1
Demo metre scales, centre zero galvo	1
Demo scale galvanometer	1
Demo scale, 0-1 V	1
Demo scale, -5 °C to +5 °C	1
Demo scale, analogue pH dial	1
Demonstration metre (interscale)	1
Desiccator discs	**5**
Desiccator knobs, top 200 mm + disc	**5**
Desiccators	**2**
Diffraction gratings, 100 lines/cm*	**12**
Digital thermometer, -50 to 300 °C**	**1**

Discharge tube holder	**1**
Discharge tube, hydrogen	**1**
Draining rack backboards and troughs	**2**
Draining racks	**2**
Electric jug kettle (cordless)	**1**
Electrode pH BNC**	**1**
Electrode pH CO-AX P14**	**1**
Evaporating basins, 70 ml and 80 mm	**30**
Eye wash bottles	**12**
Filter paper, grade 1, 15.0	**20**
Filter paper, grade 1, 18	**2**
Filter paper, grade 1, 24	**2**
Filter paper, grade 1, 12.5	**20**
Fire blankets	**2**
First aid cabinet	**1**
Flasks, Buchner, 500 ml, PL/SA	**15**
Flasks, conical, NM 150 ml, Pyrex	**15**
Flasks, RB boiling, 250 ml, Pyrex	15
Flasks, vacuum, 1 l	2
Flasks, vacuum, 450 ml	15
Flasks, volumetric 1 l	**15**
Flasks, volumetric 2 l	**10**
Flasks, volumetric, 100 ml	**15**
Flasks, volumetric, 250 ml	**15**
Flasks, volumetric, 500ml	**10**
Fume cupboard (portable) and suitable filters	1
Funnels, Buchner, plastic, demountable, 7.0 cm paper	**15**
Funnels, glass, 100 mm	**15**
Funnels, plastic, 50 mm	15
Gas jars, 150 × 50 mm	**30**

Gas lighter and battery	**1**
Gas syringe holders	12
Gas syringe steam jackets	12
Gas syringes, self-sealing rubber caps (packet)	5
Gas syringes, silica tubing	10
Gauzes, ceramic, 150 mm	**15**
Glass-cutting knives with replaceable blades	**2**
Glass tube (long) for gas diffusion experiment, with 2 matching bungs	**1**
Gloves, disposable, large, 50	**4**
Gloves, heat-resistant	**2**
Glue, PVA, for polystyrene spheres	**2**
Hazard labels sets	**20**
Hazard labels, roll (plastic), set	**1**
Heat resistant mats	**12**
Heavy-duty PVC gloves (pairs)	**4**
Hirsch funnels	12
Hofmann voltameter Pt electrodes (pair)	**2**
Hofmann voltameter stand	**1**
Hofmann voltameter, graduated	**1**
Hotplate and magnetic stirrers*	**12**
Indicator bottles, polystop, 60 ml, clear	**15**
Jugs, polypropene, graduated 1 l	5
Jugs, polypropene, graduated 2 l	5
Lids, glass jar, 75 mm	**30**
Loop handles, 150 mm	15
Magnetic followers	**20**
Mats, heat-resistant, cement mats, 200 mm	15
Melting-point tubes, open two ends, packet of 100	**10**
Micro Bunsen burners	**6**
Microscale kits	12

Model introductory sets, molymod 001	**12**
Model orbit molecular lattice sets	2
Model sets molymod inorganic	3
Model set, s, p and d orbitals	1
Model sets, molymod organic 003	**6**
Model, constructed, diamond lattice	**1**
Model, constructed, graphite lattice	**1**
Model, constructed, ice lattice	**1**
Model, constructed, sodium chloride lattice	**1**
Mortar and pestles, 95 mm, porcelain	**12**
Mortars and pestles, 150 mm, porcelain	2
Nickel-cadmium battery charger	1
Oven, 32 × 24 × 18 cm, 14 l capacity	**1**
Overhead projector with change-over bulb and port screw	**1**
pH meter (temp comp.) digital, bench type**	**1**
Pipeclay triangles, 65 mm	15
Pipette (bulb), 25 ml	**15**
Pipette fillers, 10 ml, pipe up green	15
Pipette stands, plastic (vertical)	15
Pipette, fillers, 25 ml, pipe up red	**15**
Pipettes, graduated delivery, 10 ml	15
Pipettes, graduated delivery, 25 ml	**15**
Plastic dispensing spoons (box of 1,000)	**1**
Platinum electrodes	**2**
Pliers	2
Polystyrene calorimeters and lids	**15**
Polystyrene spheres, 50 mm diameter (pack of 10)	5
Polystyrene spheres, 63 mm diameter (pack of 10)	5
Power supplies, a.c./d.c., 0-13 V, 8.5 A	12
Power supply 0-20 V variable, 6 A	**1**

Power supply, 0-25 V, 8.5 A	1
Prisms, crown glass	2
Quickfit adaptor spares	**5**
Quickfit adaptors, cone and screw B14	**10**
Quickfit bends, long B14	**10**
Quickfit dropping funnels, Cyl 50 ml	**5**
Quickfit inlet and steam tubes, MF5	**12**
Quickfit inlet for steam distillation, MF5	**12**
Quickfit Liebig condensers, 14/23	**5**
Quickfit pear-shaped 50 ml flasks	**15**
Quickfit sets, 27 BU*	**12**
Quickfit stillheads B14	**5**
Quickfit stoppers B14	**5**
Quickit RB 100 ml flasks	**15**
Quickfit 2-necked RB 250 ml flasks	**12**
Radioactivity demo kit	**1**
Retort stand bases, 250 mm × 160 mm	**30**
Retort stand rings, 100 mm, with boss	10
Retort stand rods, 500 mm × 10 mm, zinc-plated	**15**
Retort stand rods, 600 mm × 13 mm, zinc-plated	**15**
Rubber bands (packet of 100)	**2**
Rubber gloves (pairs)	**6**
Safety glasses	**30**
Safety screens, 750 × 600 × 3 mm (and support)	**2**
Sample tubes (snap-top), 30 ml (box of 140)	**1**
Sandpaper, medium sheets	50
Scalpel	**1**
Scissors	15
Screwdrivers (set) normal and Philips standard	1
Separating funnels, cylindrical, 50 ml, with stopper and PTFE tap	15

Silicone tubing, 3 mm diameter	5
Smoke cell	1
Solid-phase extraction columns and adaptors	**15**
Spatulas, chattaway, 203 mm	**20**
Spatulas, metal, Nuffield type	**20**
Spatulas, spoon end, 150 mm	**20**
Spectrometer PTI*	**1**
Spectroscopes, direct-vision*	**12**
Spill disposal kits	**2**
Stackable storage trays	20
Steam generators for gas syringe steam jacket	12
Stirring rods, glass, 200 mm	**20**
Stop-clocks (digital)	**12**
Syringes, disposable, polypropylene, 10 ml	**100**
Syringes, gas, 100 ml	15
Syringes, gas, excelo, demonstration	2
Syringes, hypodermic needles 21 G1.5	30
Tapers (wax), boxes	5
Test-tube holders, wooden	**20**
Test-tube racks, 6 holes and peg	**15**
Test-tubes, Pyrex, rimmed, 18 × 150 (box of 100)	**5**
Thermometers, GP, mercury, 10 250 °C by 0.1 °C	**15**
Thermometers, mercury, 10-110 °C by 0.1 °C	**15**
Thermometers, spirit, 10-110 °C, 305 mm	**15**
Thiele tubes*	**15**
Thin-layer chromatography plates	**15**
Tiles, spotting, polyprophylene	15
Tiles, white, 100 mm	**15**
Tongs, crucible, bow, 150 mm	12
Tripods, 200 mm height × 150 mm length, zinc-plated	**24**

Trolleys and trays	2
Troughs, glass, 250 mm	**5**
Troughs, plastic 230 × 230 mm, vertical wall	**12**
T-tubes, side arm, Pyrex, 150 × 24 mm	15
Tube, cathode ray, Teltron	1
Tube, rubber, N 6.5 × 9.5 mm, Liebig condenser 1 m	**30**
Tubes, combustion 22 × 300 mm	15
Tubes, rubber, for Bunsen burner	30
Tubes, rubber, H5 × 13 mm, heavy-duty (vacuum)	20
Tubes, rubber, N 8 × 12 mm, filter pump outlet 1 m	**10**
Tubes, rubber, N5 × 8 mm, for 6 mm soda glass	**20**
Tubing, PVC, 3 mm	30
Tubing, PVC, 5 mm	10
Tubing, soda glass, 5-6 mm	**10**
Universal indicator charts, laminated (1 packet)	1
U-tubes, side arm 125 × 15 mm	**15**
Vacuum filter pumps, metal, nickel-plated brass	**15**
Video player and television set with trolley	**1**
Wash bottles, 250 ml	**15**
Water bath, 5.5 l, with racks	1
Water baths, circular	12
Water still	1
Weighing scoops, 25 ml	15
Weighing scoops, 5 ml	30
White coats (specify size)	30
Winchester carriers	**2**
Wire, nichrome, 22 swg, 125 g	**2**
Wire-strippers	2
Write-on tapes, assorted colours	**10**

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