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Transformation of organic chemistry for teaching and learning: An analysis of Grade 12 South African textbooks and examination guidelines.

A research project submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the MSc Degree.

Fiona Newell

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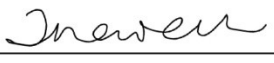
ABSTRACT

In the context of educational transformation in South Africa the organic chemistry content of science textbooks needs to be mediated by the authors of the books profoundly and flexibly so as to provide for the diverse abilities and backgrounds of South African learners. This mediation requires critical interpretation of the curriculum documents [examination guidelines], representation and selection of the instructional ideas by using pedagogical content knowledge [PCK] so as to make the content accessible to the learners and to help them prepare for examinations. The purpose of this content analysis which used PCK as a theoretical framework was to establish how the grade12 organic chemistry content has been transformed for teaching and learning by the textbook authors and what teaching methods have been used, as not all the textbooks seem to cover the same content. To capture the PCK of the authors a representation of the content or CoRe was used for each of the books analysed using the Big Ideas from the text as well as the Bishop and Denley's six knowledge bases of PCK. The study showed that although all the books analysed showed evidence of the authors' PCK none of them mediated the content sufficiently to cater adequately for the learners' needs.

DECLARATION

I declare that this research report is my own unaided work, except as indicated in the acknowledgements, the text and the references. It is being submitted in partial fulfilment of the requirements for the degree of Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other institute.

Signed  Date_____11/05/2012_____

Fiona Anne Newell

Dedication:

This project is dedicated to my family- my husband Tony and my daughters Kim and Megan.

Acknowledgements:

Without the help of many people this project would not have been possible. I would like to express my very great appreciation to Professor Marissa Rollnick for helping me figure out what I wanted my project to be about; providing direction and for all the hours she spent mentoring me.

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I would also like to acknowledge the support of my colleagues at work especially Dina who understood that I needed some extra time to complete this task.

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CHAPTER 1

1.1 INTRODUCTION

In South Africa there is a need to improve science education and increase the number of science graduates which would in turn lead to a skilled and more productive labour force. However, science education appears to be in a crisis with poor results, poorly resourced schools and inadequate teacher training. A complete change of educational policies was brought about by the political changes of 1994. These changes included a new curriculum, at the senior secondary level or FET[1] level, which was introduced into schools in 2006 and was examined for the first time in 2008. The introduction of the new FET curriculum and the National Senior Certificate Examinations in 2008 led to changes in the amount and depth of the material in the section on organic chemistry. When examinable content only is considered, this section has been expanded to a section covering about one third of the examinable, grade 12, chemistry content. This places a greater demand on teachers, learners and textbooks as previously this section was treated very superficially as it was generally left to the end and did not link into the other chemistry content.

This research looks at the effects of these changes in the organic chemistry content of the grade 12 Physical Sciences curriculum on textbooks by analysing a sample of approved textbooks to see whether there are links between the content and the manner in which it is presented and the examination guidelines. The research also focuses on how the authors mediate the content on the textbooks for teaching and learning.

1.2 RATIONALE FOR THE STUDY

After having marked the National Physical Sciences Grade 12 Chemistry Examination at the end of 2009, I found that many of the learners and the teachers were challenged by the organic chemistry section of work as it was in general answered very poorly. On examining and reflecting on my own practice in relation to this section of the curriculum, I became aware of shortfalls in my own teaching of this

[1] Further Education and Training

section as well as problems relating to the way in which the material is transformed for teaching in the textbooks for both the learners and teachers.

This research project is motivated partly by my personal response to the changes in the Physical Sciences curriculum as a teacher. The changes in the curriculum have been a challenge and an area for improvement of my own practice. This research project responds to the need for quality textbooks for both learners and teachers in the context of South African Physical Sciences education. Any changes to the curriculum are implemented by teachers in classroom practice (Fullan & Miles, 1992; Spillane, 1999).

Textbooks can be a central element of the implementation of these changes, as they are often the only resource available to teachers. Textbooks can provide the foundation for the lesson content as well as the skills that are taught. They are used to guide teaching practice as they provide ideas on how to plan and teach lessons. They can also provide language appropriate for the topic. Thus, the correct textbooks are a vital source for change in science education.

Research also suggests that learners also rely on textbooks for practice exercises and content when preparing for examinations and therefore the textbooks should also correspond to the learners' needs and should help facilitate their learning process (Richards, 2001; Stoffels, 2007; Lemmer, Edwards, & Rapule, 2008).

The information in science textbooks deals with content (written text), mathematical language, drawings, graphs, tables and images (Pinto & Ametler, 2002). According to Roth, Bowen, & McGinn (1999, p. 978)

> *"visual displays can be used to present data, illustrate abstract concepts, organise complex sets of information, facilitate the integration of new knowledge with existing knowledge enhance information retention, mediate thinking processes, and improve problem solving".*

Therefore the manner in which the content of the textbooks is mediated for teaching and learning is, in my opinion, also an essential part of implementing the changes to the curriculum successfully and this mediation of the content by the authors of the textbooks is central to the research.

Further changes to the curriculum have been implemented in various stages and the organic chemistry content that is currently being examined in 2011 is different from what was originally intended. Grade 12 teachers generally use the examination guidelines as a curriculum document to inform them of the examinable content for the final examination. The examination guidelines have also been altered in the course of the changes but have remained unchanged since 2009 and these guidelines are the ones used in this study.

1.3 AIM OF THE STUDY

The aim of this study is to determine how the grade 12 organic chemistry curriculum is transformed into a teachable form and to establish what teaching approaches are used by the authors of the textbooks. The study also aims to evaluate the alignment of the grade 12 organic chemistry subject matter with the examination guidelines.

1. 4 STATEMENT OF THE PROBLEM

In South Africa there are many textbooks available to teachers and learners but not all seem to cover the content in the same detail. Moreover, the content in some of the approved textbooks does not appear to align with what the Department of Education has set out as the examinable content for 2009 and 2010. This is hardly surprising as the publishers were required to produce the textbooks from the intended curriculum or the NCS[2] (2003) (Education, 2003) before the examination guidelines were set. This lack of foresight may have had a detrimental effect on the learners' results.

The Department of Education has deemed certain books as suitable through an evaluation process and has spent money purchasing textbooks but has been reluctant to give teachers any help with the selection of appropriate books. In the 2009 national examination, the examiners asked questions on content that was covered in some but not all of the available textbooks. This is another problem which, I believe, has to be addressed.

Research suggests that in Africa not all learners and teachers have access to textbooks and other resources and this could have an effect on learning outcomes

[2] National Curriculum Statement

(Lubben, Campbell, Kasanda, Kapenda, Gaoseb, & Kandjeo-Marenga, 2003). According to Verspoor (1991) the provision of textbooks may have an impact on learning outcomes and could be a cost effective way of improving learning results. The Department of Education appears to endorse this opinion as, according to policy, they have been supplying schools with textbooks for each learner. In a statement on curriculum review to National Assembly**,** Mrs. Angie Motshekga, the Minister of Basic Education said on 5th November 2009,

> ***"****All learners from grade 4-12 should receive their own textbooks for every learning area/subject"* (Motshekga, 2009).

In my school alone an amount of approximately R120 000 has been spent by the Department of Education on Physical Sciences textbooks for the FET phase. Expenditure on textbooks is a starting point for change but if these books do not supply the learners with vital information for their studies, the problem of inadequate textbooks persists.

In some schools these may be the only books or resources to which the teachers and learners have access. I believe that although some teachers may view textbooks as one of many sources of reference, the learners view their textbook differently, so that it becomes in many cases a single source of information while they are preparing for their examinations. Thus, learners are adversely affected by only having one textbook, especially when that textbook does not provide them with the essential requirements.

Another factor which has impacted negatively on the Physical Sciences examination results is the change in content. The organic chemistry content changed in the examination guidelines of 2009 after the initial NCS examination in 2008 and this did not really give teachers time to become accustomed to the new content. Although some in-service training on teaching organic chemistry at grade 11 and 12 levels has taken place, not all teachers were informed about it or were able to attend the training. The lack of adequate in-service training of teachers has hindered learners' progress, compounding the problem of poor science results. Although the Department of Education promised not to make changes in 2010, some changes to

the examinable content were made to both the physics and the chemistry papers in 2010.

In the context of Grade 12 organic chemistry in South Africa, there is a need to investigate the limitations of Grade 12 Physical Sciences textbooks. Teachers should be aware of the inadequacies of the books in terms of examination requirements.

“Physical Sciences” is historically one of the grade 12 subjects with the lowest pass rate. According to the 2010 Report on the National Senior Certificate Examination Results issued by the Department of Basic Education only 47.8% of the candidates who wrote passed and of these 18% scored between 30 and 40 % and this was after adjustments made by UMALUSI. This means that only 29.7% scored higher than 40%. There is therefore a need in South Africa to improve the manner in which Physical Sciences is taught and learned. It is not surprising that Physical Sciences has such a bad record in terms of its pass rate, given the above mentioned inadequacies, not the least of them being inadequate learning resources.

1.5 RESEARCH QUESTIONS

The research questions were developed to try to understand exactly what the problems are and how they can be addressed.

1. How is the organic chemistry content mediated in the approved textbooks?
2. Is the organic chemistry content of the books aligned with the examination guidelines? If not, what changes need to be made?

1.6 SEQUENCE OF THE RESEARCH REPORT

Chapter 1 introduces the research and describes the rationale of the study. It states the research questions, examines why the problem exists and summarises the aim of the study.

Chapter 2 reviews the literature with reference to the theoretical framework; textbooks and grade 12 examination guidelines on organic chemistry.

Chapter 3 contains a description of the research design and methodology. It also describes the research instruments used to analyse the textbooks.

Chapter 4 documents and attempts to analyse the data collected on textbook number one ‘Study and Master Physical Sciences’.

Chapter 5 documents and attempts to analyse the data collected on textbook number two ‘Focus on Physical Sciences’.

Chapter 6 documents and attempts to analyse the data collected on textbook number three ‘Physical Sciences Explained’.

Chapter 7 attempts to make a comparison of the three different textbooks and gives an overview of the study and discusses the findings of the study. It also gives suggestions for future research.

CHAPTER 2

2.1 TEXTBOOKS, TEACHERS AND MEDIATION OF ORGANIC CHEMISTRY CONTENT:

In spite of trainee teachers being encouraged to develop their own teaching material, most teaching originates from a textbook (Schmidt, Marohn, & Harrison, 2007). When the new curriculum was introduced in South Africa, teachers were meant to move away from the traditional teacher centred approach towards a learner centred approach and design their own teaching materials. According to Stoffels (2007) it is evident that very few teachers were actually capable or had time and other resources for doing this and teachers prefer to get help from textbooks rather than from Department of Education policy documents.

Since it appears likely that teachers and learners will continue to rely on textbooks this study attempts to investigate how the organic chemistry content provided for both teachers and learners is mediated in the textbooks. Yager (1983) suggests that over 90% of all science teachers in the United States used a textbook 95% of their teaching time. PCK should therefore be evident in the textbooks as the material in these books was developed for teaching and learning.

Textbooks have an influence on the classroom practice of teachers and the amount and quality of the help that these resources give to teachers can vary. Textbooks together with Teacher's Guides should show in detail what is supposed to happen during teaching and learning.

Content in the textbooks is mediated through the use of text; visual material such as graphs, tables, illustrations, as well as the examples and questions used to make the teacher and the learner accountable for the subject material in the text. The mediation of the content should also be manifested in the way the organic chemistry is planned, represented and adapted for the varied interests and abilities of the learners, how it is presented for instruction, in the activities for learning and in how it scaffolds learning. Scaffolding learning facilitates the learners' ability to build on prior knowledge and internalise new information. The term was introduced by theorists applying the ideas of Vygotsky's Zone of Proximal Development to educational contexts. Although Vygotsky did not use the term scaffolding he defines this as,

> *"role of teachers and others in supporting the learner's development and providing support structures to get to that next stage or level".* (Vygotsky, 1978)

2.2 THEORETICAL FRAMEWORK: PEDAGOGICAL CONTENT KNOWLEDGE (PCK):

Pedagogical content knowledge is the fusion of insight that incorporates content or subject matter knowledge with instructional practices and an understanding of learner characteristics.

According to Shulman (1986) pedagogical content knowledge includes:

> *"the most useful forms of representation of, the most powerful analogies, illustrations, examples, explanations and demonstrations- in a word, the ways of representing and formulating the subject that makes it comprehensible to others."*

Pedagogical Content Knowledge or PCK[1] involves a cycle of activities such as the teachers' comprehension of the topic; transformation of the topic into lesson plans; instruction of the learners; evaluation of his/her practice; reflection and a new comprehension of how to tackle the task next time.

PCK has been used in this study as a theoretical framework and provides a logical structure to examine the mediation of the textbooks by the authors. The textbooks analysed in this study are the authors' representations, illustrations, analogies etc of the grade 12 organic chemistry content. If textbooks are a way of promoting active teaching and learning this means that textbooks should 'set up pedagogic pathways' for teachers and learners (Ensor, Dunne, Galant, Gumedze, Reeves, & Tawodzera, Textbooks, teaching and learning in primary mathematics classrooms., 2002, p. 22).

According to Cochran, De Ruiter, & King (1993) the term, PCK, includes the teacher's knowledge of the subject matter; an understanding of the prior knowledge of the learners and the learners' pre-conceptions and misconceptions. It also includes knowledge of the curriculum as well as a general understanding of different

[1] PCK will be used in place of Pedagogical Content Knowledge

teaching methods and strategies. It is about what, when and how to teach the different topics and how to manage the classroom environment successfully.

2.2.1 ANALYSING FOR PCK:

The term PCK was first proposed by Shulman (1986) to describe how teachers use content knowledge in their teaching. PCK represents the fusion of content and pedagogy into an understanding of how the subject matter is structured, tailored and represented for instruction. PCK is how the content is represented and made comprehensible to the learners. It is a way of describing the knowledge that expert teachers have. It is made up of the teachers' knowledge of how to represent content knowledge and knowledge of the learners.

The notion of PCK has captured the attention of many researchers, some of whom have come up with modifications to Shulman's ideas. All of the modifications include subject matter knowledge as being an important prerequisite of PCK but not necessarily a separate category of a teacher's knowledge. In my opinion, content knowledge is essential to the development of PCK specific to the topic as teaching begins with the teacher's understanding of what content the learners are going to learn and what PCK is going to be employed in the process. The teacher/author of the textbook therefore needs to know what the content is first and understand it. The foundation of a teacher's science PCK is a mixture of pedagogy and understanding of the content and is a component of the teacher's professional knowledge (Shulman, 1987).

Geddis and Wood (1997) saw PCK as consisting of the knowledge required to transform content knowledge into material for teaching which expert teachers/authors are able to do, as they are aware of and understand the difficulties that their learners might experience. Teaching as a profession differs from other professions in the way that the knowledge is organised. Teachers organise their knowledge from a teaching perspective to help learners understand scientific concepts.

Teaching is about providing opportunities for learners to understand content and involves making decisions about how the content is transformed in the lesson. It involves decisions made prior to teaching, during the lesson and reflection after the

lesson about knowledge both teacher and learners have gained (Bishop & Denley, 2007). In Shulman's (1987) model for pedagogical reasoning, which comprises of a cycle of several activities that a teacher should complete for good teaching, the first step is comprehension of the content by the teacher/author. Teachers need to understand what they teach and, when possible, to understand it in several ways. This is followed by transformation of content into a lesson. Transformation involves interpreting the content, representing the content, selecting material for the lesson and then adapting and tailoring material for teaching. This is followed by the instruction (the actual teaching process) which includes a variety of teaching acts such as classroom management, presentations, interactions, group work and discipline. The evaluation of the lesson includes checking for understanding and misunderstanding as well as testing students' understanding at the end of lessons or units. Reflection is a process which includes reflecting on and reviewing and critically analyzing one's own teaching abilities and using these reflections to become a better teacher with a new comprehension of teaching (Shulman, 1987).

Various modifications to Shulman's model include a hierarchical model by Veal and MaKinster (1999). In this model, the background is the teacher's pedagogy and this encompasses three different types of PCK. These are general PCK; domain specific PCK and topic specific PCK. General PCK refers to the understanding of pedagogical concepts that an experienced teacher would have. It is more than just general pedagogy as it would include concepts and strategies specific to a certain discipline (subject specific) e.g. science (Veal & MaKinster, 1999). The domain specific PCK can be differentiated from the subject specific PCK in that it focuses on domains within science such as chemistry and physics. Topic specific PCK is the PCK a teacher has in an individual topic such as organic chemistry. These different types of PCK may be useful in categorising the data obtained in the study.

In Bishop and Denley's (2007) model of PCK, teachers' professional knowledge is likened to a "spinning top" where the individual knowledge bases merge when the top is spun. When teachers become experts they are able to merge their knowledge bases into one. The way I interpret this model is that all seven categories merge into one with PCK being central and being a blend of the other categories. The other

categories have equal ranking and no one of them has more emphasis placed on it than another. This is illustrated by the diagram of the model below.

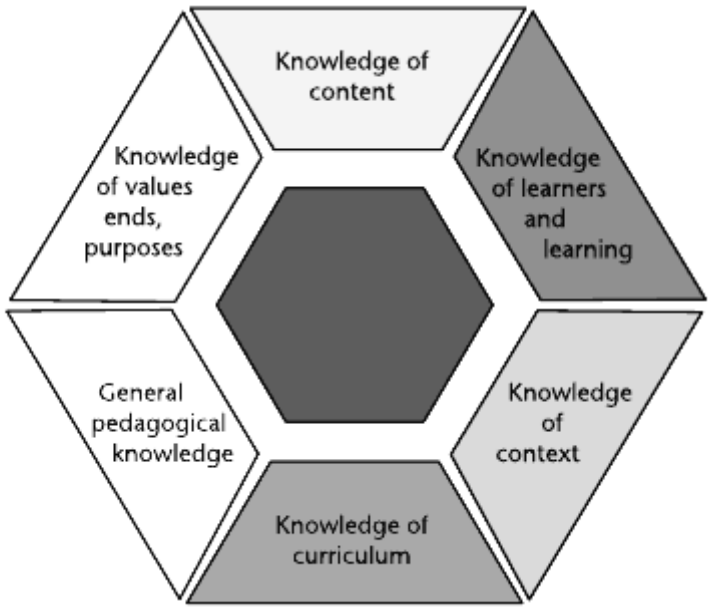


Figure 2.1 Bishop and Denley's model of PCK (2007)

Bishop and Denley (2007) argue that the thinking of the teachers in selecting material for teaching and the application of the knowledge as more important than the pieces of knowledge. This model of PCK was used to analyse the data in this study because it represents a powerful way to understand effective teaching and learning. It shows how the authors used their PCK to present information to the learners by blending content and pedagogy.

2.2.2 CAPTURING PCK:

Pedagogical content knowledge is tacit, it is therefore elusive and complex to articulate. It involves knowledge and expertise but not in a way that can be written down easily. It is characterised by specialist or expert educators who work, act and make judgements without making any reference to the knowledge behind their decisions. It appears to be gained through the personal experiences of the individual educator.

Due to the tacit nature of expert teachers' PCK it is difficult to capture and portray PCK (Loughran et al 2004). It is also difficult for teachers to explicitly separate PCK

from content knowledge. I used a CoRe[2] or Content Representation in this study to map the 'pedagogic pathways' of the authors. The CoRe was developed by Loughran et al (2004) to represent successful teachers' PCK. The CoRe provides an overview of how teachers approach the teaching of the whole of a topic and the reasons for that approach. This includes what content is taught, as well as how and why it is taught. The CoRe provides a useful foundation on which a general idea of the authors' PCK for a topic can be expressed. It may indicate what made the author decide on teaching strategies provided in the textbooks and help link practice and the content (Loughran, Berry, & Mulhall, 2006). The Big Ideas in the CoRe refer to the science ideas in the topic that the author sees as essential for learners to understand the topic. The prompts in the CoRe allow the topic to be 'unpacked' (Loughran, Berry, & Mulhall, 2006).

2.3 TEXTBOOKS AND THE CURRICULUM:

In South Africa, one of the African National Congress (ANC) government's priorities when it took power in 1994 was to reform education (Rogan & Grayson, 2003). These changes were essential to the new South Africa and included a policy shift to outcomes based education (OBE), child- learning and performance-based assessment. According to Jansen (1999, p9) "OBE has triggered the single most important curriculum controversy in the history of South African education". According to Rogan & Grayson (2003) the implementation of these reforms has not proceeded according to plan and the program has been "inadequately resourced and supported and hopelessly underestimated". The implementation has been slow and difficult and is probably due in part to the large difference in the quality of schools, teachers and the learning that takes place in schools.

When the new curriculum was introduced to South Africa, schools were given more freedom and responsibility to plan how the content is taught to achieve the outcomes and assessment standards. Teachers were meant to move to a learner-centred approach and design their own teaching materials. However, it became evident that very few teachers were actually capable of doing this (Stoffels, 2007; Rogan, 2004).

[2] CoRe will be used in place of Content Representation

The new curriculum was meant to be learner-centred and teachers were encouraged to use a variety of resources for teaching and assessment which should cater for learners' needs and experiences. The original NCS (Education, 2003) provides core concepts but is not as prescriptive as the old curriculum. It was thus up to the textbook authors to interpret the demands of the curriculum and produce teaching materials for schools. Most schools have decided to use commercially prepared textbooks that are available in many classrooms and this material is often used basically unaltered by the teachers. It appears as if many teachers believe that the authors of the books somehow define their own classroom practice (Stoffels, 2007). In some schools like my own the Department of Education has supplied textbooks which they have chosen from a list of approved textbooks which limits the choice of the individual teacher.

2.4 QUALITY OF TEXTBOOKS

In spite of textbooks being used in most classrooms, there appears to be very little literature about the textbooks used in science education in South Africa. The authors and publishers of the textbooks try to ensure that certain criteria are fulfilled so that their books will be commercially viable and conform to the Department of Education's selection criteria and this influences the way in which the content is presented (Stoffels, 2007)

Elsewhere, concerns have been raised about the number of errors in American physical science textbooks. According to Hubisz (2003), the errors are varied but relate to scientific accuracy; adherence to a realistic portrayal of science and the pedagogic effectiveness of the material for the level of learner ability, as well as poor reading abilities of the learners. Many of the errors involve informal and careless use of language and workbooks and practice materials are often badly designed. Some textbooks contain very little text and pictures, sidebars etc are interspersed in the texts. The textbooks are not accurate, some lack hands-on activities and in some instances the science is oversimplified, making it meaningless. Teacher's guides often fail to provide information to the teachers on learners' pre-conceptions and misconceptions. The instructional strategies are not always likely to promote learning. By contrast good textbooks challenge the learners and the teachers to

interact with the authors and engage with the subject matter (Hubisz, 2003; Ball & Feiman-Nemser, 1998).

2.5 FUNCTIONS OF TEXTBOOKS

A textbook is a teaching tool which presents material that is defined by the curriculum and can, in effect, constitute the curriculum by offering structured ideas for teaching and learning (Khutorskoi, 2006).

Textbooks are meant to have different functions. They are meant to be a source of information in a form that is accessible to learners and teachers. The information should be stipulated by the curriculum and should serve as a tool for learning, which includes learning on one's own. Textbooks have been criticized for their lack of connection to real life. In defining a textbook it is important to determine the relations and interactions between the textbook and the educational reality in which the learners and teachers find themselves (Khutorskoi, 2006).

> "The textbook should be a model that portrays the aims, principles, content and technology of the corresponding educational process" (Khutorskoi, 2006, p. 84).

This means that if textbooks do not offer anything other than the content to be learned, then the textbooks can be considered to be merely tools to reproduce content information. Learners may be able to reproduce the content but will not be able to interpret and analyse problems. In other words, the textbook should not only organise curriculum content but also encourage learners to be engaged with the activities and exercises (Khutorskoi, 2006). This function of the textbook can include research activities; creative projects; comparisons of different views and approaches; evaluation and reflection on what has been learned and read (Khutorskoi, 2006).

2.6 SOUTH AFRICAN PHYSICAL SCIENCE TEXTBOOKS

A TIMMS (2007) study suggests that the content of topics in American textbooks is covered very superficially and that this is one of the reasons for the poor performance of learners in the USA (Stoffels, 2007) . In my study, the intention is to look at the PCK evident in South African organic chemistry texts, how textbooks help teachers to make decisions about what is taught and how it is taught, whether the

Teacher's Guide helps with teaching and planning and whether practical experiences are available in the textbooks for the teachers to adapt for use in the classroom.

According to Stoffels (2007), the authors of South African science textbooks appear to have tried to ensure that the content has been presented in an outcomes-based learner- fashion that would meet the approval of the selection panel. However, he argues that the selection process was flawed as the Department of Education selection panels had too much power and the process by which the books were evaluated was too technical and superficial. The process was done by using a checklist to see if the book covered, for example, the correct learning outcomes. This process has allowed for books that are too superficial and do not address the conceptual needs of the learners to find their way into schools.

2.7 TEXTBOOKS AND EDUCATIONAL REFORM

Powell and Anderson (2002) suggest that "educational reform and curriculum material are often discussed together" and this is the case in the South African context where educational reform has been implemented. The role of the materials used in reform needs to be reviewed from the perspective of the classroom practice as these materials have a role in improving the teaching and learning of science. This means that the textbooks that a teacher uses are likely to influence not only what is taught but how it is taught. The design of the textbook can also influence the changes to an individual teacher's thinking and practice as well as to the teacher's knowledge and beliefs. There is a need to find out what materials are being used and if they support reform, as well as how they influence classroom practice. They assert that the books used can impact on how the reform is accomplished as the teaching materials are 'vehicles' for conveying the reform. They also state that professional development can occur through the use of the textbooks available and teachers may acquire tools which they access through using textbooks. Textbooks should be designed to challenge teachers to think differently and provide insight on how to teach and should not just be material on what to teach.

All teachers do use some sort of teaching resource materials while teaching and although there is a view that the better teachers prepare their own material from a

variety of sources, the reality in some South African schools is that a single textbook is the only source of information that a teacher and learner may have.

2.8 TEXTBOOKS, TEACHERS AND LEARNERS

The importance of textbooks as a part of science teaching has been supported by other researchers (Chiapetta, Sethna, & Fillman, 1991; Gottfried & Kyle, 1992; Yore, 1991). Key concepts in science are difficult to master because science is laden with technical information. Authors sometimes simplify the information in such a way that learners are unable to acquire a coherent understanding of the text. This is especially true for learners with poor scientific knowledge or scientific misconceptions. This can lead to negative attitudes to textbooks, poor processing of the text and a lack of motivation to master the text (Graesser, León, & Otero, 2002)

According to Peacock & Gates (2000), the relationships between the textbook, the learner and the teacher are in the form of a triangle. They suggest that when a teacher uses a range of different text types and pedagogical styles and gains teaching strategies from the textbooks these are then passed on to the learners. It may be more appropriate for teachers to produce their own materials but the reality is that due to time constraints textbook material is often used. Teachers use textbook material for their own learning and in the preparation of lessons; as starting points for new topics, to guide learners through practical activities and when practical activities are inappropriate or the school does not have the equipment necessary for the activity (Peacock & Gates, 2000). In South Africa the Department of Education is trying to ensure that all learners have access to textbooks and libraries.

2.9 ORGANIC CHEMISTRY CONTENT IN TEXTBOOKS

Bucat & Mocerino (2009) emphasize the importance of both images and words in the understanding of chemistry. There are many challenges to be addressed in producing good textbooks with precise use of language and good visual representations. One of these is the portrayal of molecular structure which is often done in a variety of ways each of which has advantages and disadvantages. Ordinary structural formulae, for example, do not inform the learners about bond angles and the flexibility of the carbon chain due to rotation around single carbon to carbon bonds. The same structure can be represented in different ways to

emphasize different features of the molecule and learners may fail to distinguish between reality and the different representations (Bucat & Mocerino, 2009).

According to Chandrasegaran, Treagust, & Mocerino (2008) learners do not always understand changes that occur at the particulate or sub-microscopic level and often fail to grasp the formulae and symbols that textbooks use to represent chemical equations. The understanding of these representations is essential for the understanding of organic chemistry. They indicate that learners' misunderstandings are related to the representations that are used in textbooks to describe and explain chemical phenomena.

These representations can be macroscopic or observable and relate to phenomena that are both concrete and visible. They can also be microscopic or molecular representations which attempt explanations at the particulate level and can also be symbolic. Learners have to learn to deal with all of these kinds of representations simultaneously as textbooks jump from one to the other. Many teachers and textbooks do not help learners make the appropriate connections between these abstract representations (Chandrasegaran, Treagust, & Mocerino, 2008). This study intends to analyse how these visual representations are dealt with in the textbooks and whether they are explicitly emphasised in the text.

Visual semiotics, which are part of chemistry, may be regarded as "equivalent" to words according to Kress & Van Leeuwen (2006). When studying language, grammar is sometimes studied in isolation from meaning and this could be the case with the chemical inscriptions or visual statements of chemistry used by the authors of the chemistry textbooks. These visual inscriptions are specific to chemistry and communicate specific messages, the meaning of which should be clear to teacher and learner (Kress & Van Leeuwen, 2006).

The value of chemistry teaching is, according to Treagust, Chittleborough & Mamiala (2003) dependent on the teachers'/authors' ability to communicate and explain theoretical chemical concepts. The information needs to be at a suitable level for the learner without going beyond the learner's level of understanding or over simplifying the content. It is necessary that the explanations are learner-friendly and are

compatible with the learners' existing knowledge (Treagust, Chittleborough, & Mamiala, 2003).

2.10 IMPLICATIONS FOR THIS STUDY:

Since this study attempts to investigate the authors' PCK with regard to the grade 12 organic chemistry content, the literature review suggested that due to the tacit nature of PCK analysis of the data would be difficult. To use PCK as a theoretical framework a content representation or CoRe together with Bishop and Denley's Spinning Top Model could be used to analyse the textbooks.

The review also showed that many teachers and learners rely heavily on textbooks and that therefore textbooks have an influence on teaching and learning. The authors' PCK would be evident in different forms such as text, visual material such as graphs, tables etc. and how the organic chemistry is planned, represented and adapted for the various different abilities and interests of the learners.

In the context of South African education the literature review indicated that there is an urgent need to improve the quality of both teaching and learning in the classroom as learners have historically performed poorly in physical sciences.

In chapter 3 the research design and methodology is described as well as the research instruments used to analyse the textbooks.

CHAPTER 3

3.1 INTRODUCTION:

The literature review in the previous chapter focused on literature pertaining to teaching and learning, Pedagogical Content Knowledge, grade 12 organic chemistry and textbooks.

This chapter provides an outline of the research design as well as the methods that were employed to collect the data from the three textbooks that were examined during the study. It also discusses the instruments used to collect the data.

3.2 TYPE OF RESEARCH:

This study entails content analysis. Traditionally, content analysis involves a concept which is chosen for examination, and the analysis involves finding and then quantifying its presence (Opie, 2009). As this study intends to provide a detailed analysis of the mediation of the organic chemistry content in a range of textbooks, as well as how the examination guidelines align with the textbooks, there was a need to make inferences about the authors' PCK.

While the alignment to the examination guidelines was reasonably easy to establish it was much more difficult to extract the authors' PCK which is tacit. To try to limit subjectivity and increase the reliability and validity of the research, tools were used to help with the analysis. The research attempts to examine both the content and how this content is mediated for both teachers and learners. The focus is on how selected authors have chosen to represent the content and how the authors' PCK is evident in the text. To be able to do this the text had to be broken down into manageable categories and then coded before being analysed.

Using this type of analysis, I attempted to describe and to make inferences about the likely effects of the organic chemistry content on both teaching and learning. One of the advantages of this type of analysis is that it focuses on the actual content and allows the researcher to make inferences about the comprehensiveness of the content coverage (Opie, 2009). It also allows the researcher to reveal differences in content and identify omissions in content made by the authors. A major benefit of this type of analysis is that is systematic and reliable. Other advantages of using

content analysis are that it allows the researcher to look directly at the textbooks their alignment with the examination guidelines; it can also provide historical and cultural insights; it can allow for both qualitative and quantitative aspects of the textbooks to be analyzed; it can be used to statistically analyze a text; it provides insight into the authors use of thought and language and is an unobtrusive way of analyzing the interaction between the textbooks. However, content analysis can be time consuming and can just consist of word counts and often disregards the context that produced the text (Stemler, 2001).

The content analysis was started by identifying the research questions and then choosing the sample of textbooks. The strategy for selecting the textbooks was convenience sampling as the books were available at my school and they were also on the approved textbook list. These books had been supplied to the school by the Department of Education. The textbooks were then coded into manageable categories. This was done by using a textbooks analysis tool which reduced the textbooks to predetermined categories which allowed the identification of words, codes and patterns which related to the research questions.

All three of the textbooks should include the following learning outcomes or LOs:

- LO1- Scientific Inquiry and Problem solving Skills. The learner is able to use process skills, critical thinking, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts.
- LO2- Constructing and Applying Scientific Knowledge. The learner is able to state, explain, interpret and evaluate scientific and technological knowledge and can apply it in everyday contexts.
- LO3- The Nature of Science and its relationships to technology, society and the environment. The learner is able to identify and critically evaluate scientific knowledge claims and the impact of this knowledge on the quality of socio-economic, environmental and human development.

3.3 TRUSTWORTHINESS OF THE STUDY:

Good research practice requires the researcher to try to triangulate or use more than one method to collect data to enhance the validity of the outcomes of the research (Opie, 2009). As can be seen from the methods used to collect data this was done in this study.

The issues of reliability and validity in this study are similar to those of other research methods. The reliability of content analysis concerns whether or not the researcher can code and classify the data in the same way over a period of time. In an attempt to minimize coding errors a peer was asked to code some of the data in both the textbook analysis and the representation of the content and this was then compared with my coding of the data. The validity of the content analysis relates to how the categories correspond to the conclusions which are drawn and how these conclusions can be generalized. This depends on how the categories have been chosen and how reliable the categories are.

The data obtained in this study are credible and can easily be checked. I have included the pages from the textbook in appendix 2 on a CD for scrutiny.

The tools used in the analysis were all adapted from existing instruments that are already dependable. However using both the textbook tool and the CoRe do involve the researcher making judgments. An example of this is the decisions about what I considered the authors' Big Ideas to be from the text. I have included copies of the tools in appendix 1. I also tried to examine the textbooks within a certain time frame but this was not possible as this research was done part time.

Although I had seen and previously used some of the textbooks, I had not previously analyzed them as carefully as was done in the data collection. I attempted to plan and structure the research in a systematic way which will ultimately become public. All observations were systematically documented. Excerpts of the data have been included so that it can easily be checked on at a later stage if necessary. Increasing the number of textbooks analyzed would increase the level of significance of the research (Opie, 2009) but this would have made the collection of data too time consuming.

3.4 SAMPLE:

The data were collected from three textbooks and corresponding teacher's guides, and the 2009/2010 examination guidelines using the instrument described below. No new examination guidelines were issued by the Department of Education in 2011. The three textbooks I examined were all selected from the list of approved textbooks for grade 12 Physical Sciences from the Department of Education. This list consisted of 12 books, each with a teacher's guide, which have been published by 10 different publishers. The textbooks that were chosen are a convenience sample and were all books that the Department of Education sent to my school or are accessible to the learners in my school as Learning and Teaching Resource Materials and are all included on the list of approved textbooks by the Department of Education. Only the organic chemistry material from each of the books was examined in this study together with some of the general features of each book. The three books are described in chapters 4, 5 and 6 and they are:

1. Study & Master Physical Sciences (Kelder, Govender, & Govender, 2007) published by Cambridge University Press, pages 209-237.
2. Focus on Physical Sciences (Hendricks, Sadeck, & Spies, 2007) published by Maskew Miller Longman, pages 151-169.
3. Physical Sciences Explained (Jones, Davies, & Mgogi, 2007) published by Juta Gariep, pages 150-178.

3.5 TOOLS FOR ANALYSIS:

The instruments I used in this study were a textbook analysis tool which I developed and adapted from various educational sources, a CoRe or Content Representation (Loughran, Berry, & Mulhall, 2004) and the 2009/2010 Department of Education examination guidelines. The examination guidelines were used as a checklist to see whether the content in the textbooks aligned with the examinations.

3.5.1 TEXTBOOK ANALYSIS TOOL

The textbook analysis tool (AAAS, 2001; Andersen, 2010; Bishop & Denley, 2007; Peacock & Gates, 2000; NJDOE, 2010) which can be found in Appendix 3 consists of a series of prompts about aspects of the content of the chapter on organic

chemistry. The prompts in the tool were standardized and the same instrument was used on all three textbooks. The prompts were arranged to sort the data. I asked one of my peers at my school to use the tool to see how closely our responses matched. The responses were in all cases fairly similar.

Prompts included information on organisational features, whether the activities provided for the learners were applicable to a diversity of abilities, interests and learning styles; whether the activities supported the learning outcomes, whether the text books aligned with the examination guidelines etc. These prompts were selected in discussions with my supervisor as to which would be appropriate to use to extract relevant information from the textbooks. Not all of the data that was collected was used in this research project as the amount of data collected was substantial.

The criteria were chosen to provide some general observations about the textbooks; to ascertain what teaching strategies are used in the textbooks and whether there is evidence that the material has been transformed into a teachable form (the authors' PCK) ; as well as the alignment of the textbooks with the examination guidelines. The criteria were chosen after discussion with my supervisor as to which would be suitable in the data collection process.

The tool included both closed and open prompts. The closed prompts are to do with organization; layout etc. The open prompts allowed a freer response but these were obviously more difficult to analyze. The tool was intended to provide a way in which the textbooks could be evaluated. Each prompt was based on previously developed checklists. The prompts were meant to look at general characteristics of the book as well as scientific terminology and pedagogical principles. The scientific terminology used by the authors was expected to relate to the content in the examination guidelines as well as being scientifically correct.

In this study I considered learning and teaching to be an active process. The textbooks should be a guide for both learner and teacher. The learner should be able to construct knowledge from the learning experiences in the textbooks. The prompts in the tool were chosen to see whether the textbooks do cater for these experiences by containing social interactions, relevance to the socio-cultural environment, have learning activities that cater for second language learners etc.

3.6 ANALYSIS OF DATA

Data analysis involves the processing of the data so that it becomes meaningful and findings can be communicated to the reader. This involved organizing and examining the data to detect patterns, themes and relationships. These patterns, themes and relationships have to then be explained, interpreted, critiqued and theories generated. In other words, the researcher tries to make meaning of the data (Hatch, 2002).

Since some of my data were obtained from the textbook analysis tool, the data were already in different categories. The data from the tool were analyzed using typological analysis. These categories have been obtained by adapting already existing analysis tools as well as commonsense and my knowledge about PCK to align with my research questions.

Having a pre-set course of action should take less time as some categories have already been found. However, it did not preclude the idea that more categories could be found while the analysis is being done (Hatch, 2002).The research questions specify grade 12 organic chemistry content, so only the sections on grade 12 organic chemistry specified in the examination guidelines and not each entire textbook was analyzed. This was further limited to the three textbooks under review.

The examination guidelines for 2009/2010 which can be found in Appendix 3 were also used as a checklist to see whether any content was missing from each textbook.

I did not choose to interview the authors of the books as this would also have been very time consuming, if it were possible to get their permission. Some of the books have multiple authors and I would also need to know which author was responsible for the organic chemistry material. This type of strategy would require a vast amount of interpersonal skills and setting up the interviews would be very time consuming.

3.6.1 CONTENT REPRESENTATION

A CoRe (Loughran, Berry, & Mulhall, 2004) or content representation, which can be found in Appendix 3, was used in this research to provide an overview of how the authors approached the teaching of the whole topic and this includes what content is

taught, how and why. The “big ideas” are what the authors see as being the crux of the particular topic under consideration. The prompts allow an insight into the authors’ reasons for choosing the ways of representing the topic. For example the response to the prompt “What you intend your learners to learn about this idea?” reveals what the author thinks the learners should be able to learn. The response to the prompt, “why it is important for the learners to know this?”, shows the authors’ knowledge of what is relevant to the learners’ everyday lives and how it impacts on other learning areas. The authors also had to make decisions about what should be included or excluded and what the potential difficulties may be while teaching the topic. They need to show contextual knowledge, general pedagogical knowledge as well as ways of monitoring progress of learners.

3.7 ETHICS

This study examined material in the public domain such as textbooks, teacher’s guides, the curriculum, examinations and examination guidelines and these do not need ethics clearances. An ethics protocol number was, however, obtained.

3.8 CRITIQUE OF DATA COLLECTION METHODS

In this study a substantial amount of data were produced some of which is beyond the scope of this project. One of the disadvantages of data triangulation is the large amount of time needed to sift through the data when compared to that of having only a single strategy.

In the development of the CoRe the authors of the textbooks were not interviewed and so the CoRe was developed from only one perspective.

Chapter 4 documents and attempts to analyse the data collected on textbook number one ‘Study and Master Physical Sciences’.

CHAPTER 4

4.1 INTRODUCTION

In this chapter the textbook 'Study and Master Physical Sciences' and how the authors have mediated the organic chemistry content, is described.

The cover and essential details are shown in Table 4.1 and Figure 4.1.

Table 4.1: Details of textbook Study & Master Physical Sciences

Authors	Karin H. Kelder; Derick Govender, Jagathesan Govender
ISBN Number	9780621694613
Publisher	Cambridge University Press
Grade	12
Series	Study and Master Physical Sciences Grades 10-12
(FET Phase Cambridge University Press African Branch)	2007

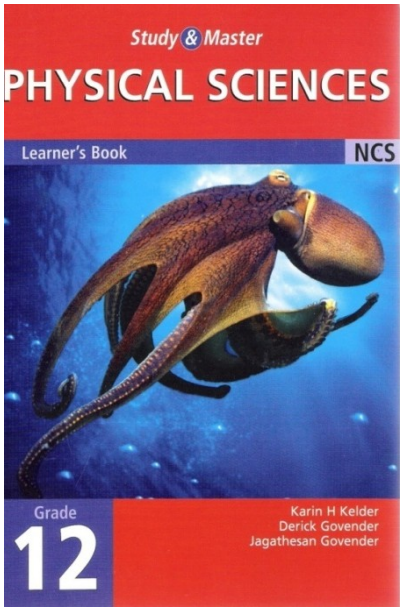


Figure 4.1: Details of Study and Master Physical Sciences. (Cambridge University Press Core South African Textbooks, 2011)

4.1.1. THE LEARNER'S BOOK

The learners' book (Table 4.1 and Figure 4.1) was first published by Cambridge University Press in 2007 in Cape Town, South Africa. The 2007 edition is the one used in this research project. The book is 17cm by 24cm and is smaller in size than the other two textbooks reviewed. The section on organic chemistry is found in Module 4, unit 3, (page 209) and consists of 29 pages which include content, diagrams, tables and 'in chapter' questions etc. This, however, does not include the section on organic macromolecules. The total number of pages in the book is 416. Assuming that approximately half of the book is devoted to chemistry this means that approximately 7% of the book is dedicated to one third of the current examinable content for chemistry. A summative assessment on the entire module is also included (page 266). According to the publishers this book:

> *"Study & Master Physical Sciences takes a fresh and innovative look at the world around us and links science to our everyday lives. All case studies and information on specialized fields, companies and institutions have been personally researched by the authors and verified by experts"* (Cambridge University Press Core South African Textbooks, 2011).

The layout of this chapter is consistent with other chapters within the book. Figure 4.2 below shows a typical introduction to a unit from this book.

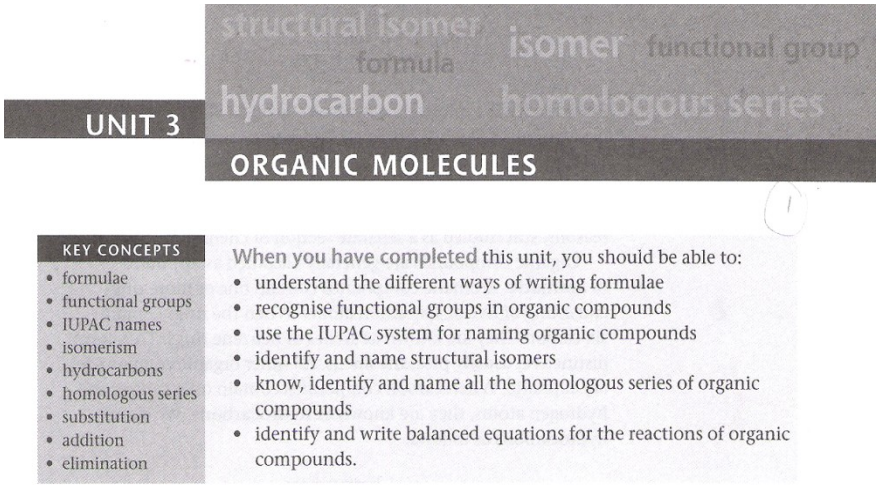


Figure 4.2: Introduction to unit 3, Study and Master Physical Sciences[1]

[1] The statement in the table above should read: name all the members of a homologous series.

The sequence of the chapters is logical and the chapter contains clear and comprehensive instructions or signposts. None of the chapters in the book contain summaries. A summary of the content of the chapter would make the content easier for learners to understand and learn the material presented.

The learners' textbook covers the grade 12 work only and is divided into six modules:

- Mechanics
- Waves; Sound and Light
- Electricity and Magnetism
- Matter and Materials
- Chemical Change
- Chemical Systems

There is a section at the start of each unit that indicates the important concepts covered in the unit as well as the Learning Outcomes and Assessment Standards. According to the publishers:

> *"The Learner's Book includes unit openers that highlight the key concepts covered in each unit and features that show the Learning Outcomes and Assessment Standards covered in each activity. Definitions and formulas are clearly explained and highlighted in boxes for easy reference.*
>
> *Realistic case studies and 'Did you know' sections provide additional relevant information. An opportunity for summative assessment is presented at the end of each module"* (Cambridge University Press Core South African Textbooks, 2011)

The learners' textbook also includes a section for the learners on how to use the book as well as the learning outcomes and assessment standards.

The reading level of the chapter is appropriate for the level or grade being taught. I used two paragraphs chosen at random in the chapter and used the Flesch Kincaid

Reading Ease Test contained within Microsoft Word 2007 to see if the reading level was appropriate. The output grade level found for this textbook is 12.4, which is appropriate for grade 12. However, this level may not be appropriate for second language learners as the language used in the texts is fairly difficult. Language in scientific textbooks is usually fairly demanding and the scientific language used is appropriate to each new topic. It is beyond the scope of this study to determine whether or not the language is too difficult for second language learners and could be a starting point for further research.

One of the challenges of designing a textbook is deciding on the size and format of the print. To check whether the size and format of the print was appropriate; I measured the approximate print size from the bottom of the lowest descender (e.g. 'g' or 'p') to the top of the highest ascender (e.g. 'f' or 'd'). This value was then converted to points in the Pica system which is used in the USA and the UK using the conversion 1pt=0.3614mm. The headings and text in this book ranged from +/- 10pt to +/- 12pt. The general guideline for printed text is to use between 11 and 14 point font regardless of the audience and this appears to be the most common size for print in most media. The text in this book gives the appearance of being dense and difficult to read due to the way in which the words and paragraphs are spaced. This may be due to the fact the print size is measured vertically and not horizontally.

The format of the book is visually appealing and interesting. The information is presented by the authors in many ways: text boxes; pictures, structural formulae etc. Examples of real life applications are given for example the trivial names neo and iso[2]; welding with 'acetylene'; rubber trees and latex etc. These are given in the form of pictures together with some explanatory text. The authors have also included non-text content in the form of tables, structural formulae and pictures into the text which are accurate and well integrated into the text. In this section10 tables and 9 pictures were found within the text together with many equations and structural formulae. These were all correctly and appropriately referenced to the text.

[2] In the early stages of the development of organic chemistry the names of compounds were often based on their history or source. Common names of alkanes use the prefixes normal (n), iso- and neo-.
The iso - alkyl group is one, in which a -CH_3 branch is present at the end of the chain.
When two -CH_3 branches are present at the end of the chain the alkyl group is designated as neo alkyl group.

The activities in a text should apply to a diversity of abilities, interests and learning styles. In this textbook there are examples of tasks calling for rote; recall and application. The activities in the chapter include guiding questions which encourage the development of higher thinking skills for example on page 237 (Figure 4.3) where learners are told that heptane undergoes an elimination reaction to produce an alkane with a chain length of three and a branched alkane with four carbons. They are asked to write down a balanced equation using structural formulae and to give the IUPAC[3] names of all the organic molecules involved in the reaction.

4. Heptane can undergo an elimination reaction to produce an alkene with three carbon atoms and a branched four-carbon alkane.
   a) Write a balanced equation using structural formulae for this reaction.
   b) Give the IUPAC names of all the organic molecules involved in the reaction.
5. Consider the compound ethyl propanoate.
   a) To which homologous series does this compound belong?
   b) Name the most distinctive characteristic of this homologous series.
   c) Give the functional group of this series.
   d) Name the carboxylic acid and the alcohol which reacted to form ethyl propanoate.
   e) Using structural formulae, write a balanced equation for the formation of ethyl propanoate.
   f) Why is concentrated sulphuric acid added to the reaction mixture?

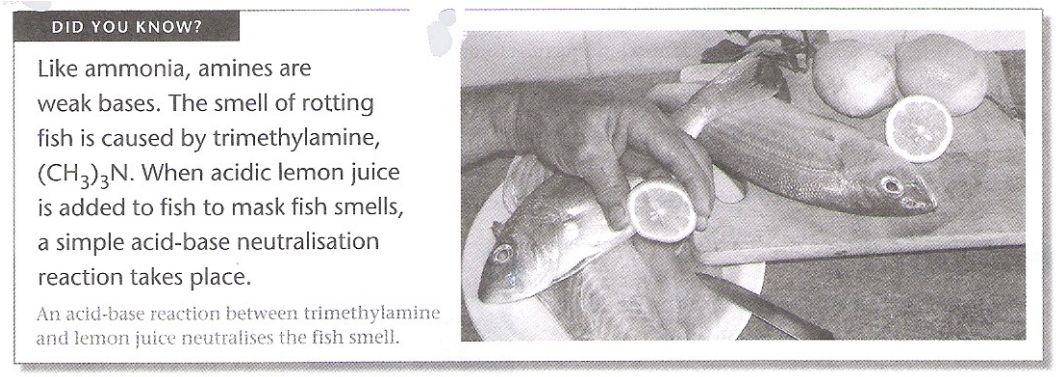
Figure 4.3: pg 237 Study and Master Physical Sciences

Activities are integrated into the chapter together with a summative activity at the end of the chapter. The activities include applying IUPAC rules and functional groups; investigating addition and substitution reactions of the alkanes and the alkenes; preparation of an ester and applying organic reactions. However, the textbook does not contain a glossary of terms which would be beneficial to the learner while completing the activities and studying for tests and examinations.

Learning outcomes and assessment standards are given at the beginning of each activity. However there are no questions in the unit which focus specifically on Learning Outcome 3 which relates to the learners ability to identify and critically evaluate scientific knowledge claims and the impact of this knowledge on the quality of socio-economic and human development. However, ten real life contexts were

[3] This chemical nomenclature is a set of rules to generate systematic names for chemical compounds. IUPAC nomenclature is used worldwide. It is developed and kept up to date under the auspices of the International Union of Pure and Applied Chemistry (IUPAC).

mentioned in the chapter. An example of this type of text is found on pg 228 (Figure 4.4) in the form of a text box “Did you know” about the smell of amines in rotting fish. It refers to the acid-base reaction between trimethylamine and lemon juice which eliminates the fishy smell. In other words the authors seem to see Learning Outcome 3 as peripheral rather than central to learning.


DID YOU KNOW?

Like ammonia, amines are weak bases. The smell of rotting fish is caused by trimethylamine, $(CH_3)_3N$. When acidic lemon juice is added to fish to mask fish smells, a simple acid-base neutralisation reaction takes place.

An acid-base reaction between trimethylamine and lemon juice neutralises the fish smell.

Figure 4.4: Did you know?

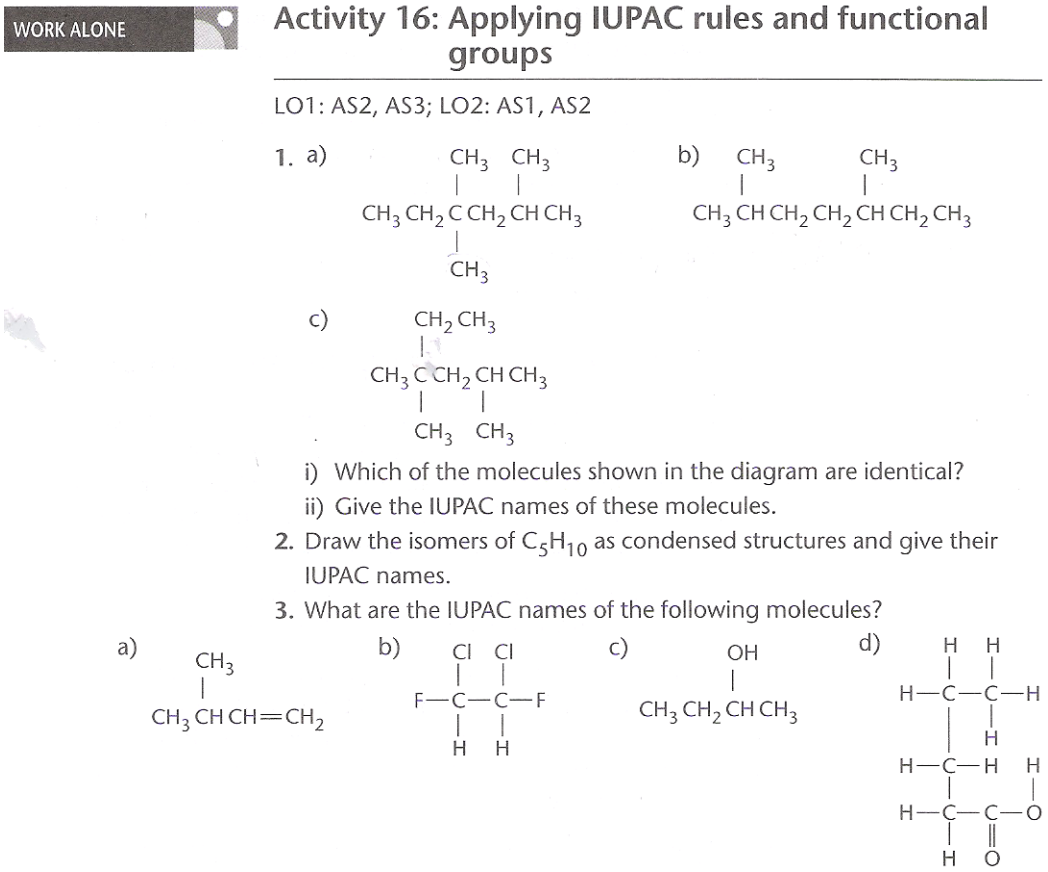
4.1.2 THE TEACHER’S GUIDE

The Teacher’s Guide follows a similar format being divided into the same six modules. It also includes sections on:

- The National Curriculum statement
- Outcomes Based Education and Assessment
- Learning Outcomes and Assessment Standards
- Planning
    - Phase Programme/Subject framework
    - Work Schedules
    - Lesson Plans
    - General Guidelines for Physical Sciences
    - Assessment Grids and Useful contacts
    - Answers to all of the activities in the learners’ book are also provided

The Teacher’s Guide also provides reproducible assessments for different types of tasks. It is evident from this that the authors showed general pedagogical knowledge, knowledge of values, ends and purposes, general content knowledge

and knowledge of the curriculum, by making sure that the teachers had access to a large amount of extra information not necessarily required by the learners. The Teacher's Guide includes the answers to the four activities found in the chapter. An example of this is Activity 16: Applying IUPAC rules and functional groups shown below in Figure 4.5.



WORK ALONE

Activity 16: Applying IUPAC rules and functional groups

LO1: AS2, AS3; LO2: AS1, AS2

1. a)

b)

c)

i) Which of the molecules shown in the diagram are identical?

ii) Give the IUPAC names of these molecules.

2. Draw the isomers of C_5H_{10} as condensed structures and give their IUPAC names.

3. What are the IUPAC names of the following molecules?

a)

b)

c)

d)

Figure 4.5: Applying IUPAC Rules and functional groups

The Learning Outcomes and Assessment Standards are given for each activity. Learning outcomes are specific to each subject. A learning outcome is a statement that defines the intended outcome of teaching and learning. It is a description of the knowledge skills and values that the learners are expected to acquire by the end of the FET phase. The learning outcomes each have their own assessment standards. The learning outcomes and assessment standards set the criteria that provide evidence of what the learner should know and should be able to do at the end of a

specific grade. These learning outcomes would be applicable to all three textbooks. The learning outcomes or LOs are: [4]

- LO1- Scientific Inquiry and Problem solving Skills. The learner is able to use process skills, critical thinking, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts.
- LO2-Constructing and Applying Scientific Knowledge. The learner is able to state, explain, interpret and evaluate scientific and technological knowledge and can apply it in everyday contexts.
- LO3- The Nature of Science and its relationships to technology, society and the environment. The learner is able to identify and critically evaluate scientific knowledge claims and the impact of this knowledge on the quality of socio-economic, environmental and human development.

However the answers to the activities are not given at the back of the learners' book so that the learners do not have access to the answers while they are working on the own. If learners are meant to interact with the material independently, while doing homework or preparing for tests and examinations, the lack of answers to exercises does not allow them to find their own areas of weakness and address these areas on their own.

No extra information is given for the teacher on how to teach the section; what the learners' misconceptions might be or what sections in the unit link to previous knowledge such as intermolecular forces. None of the activities in this unit includes Learning Outcome (LO3) type questions although there are a few instances where the authors have shown that organic chemistry is relevant to life.

4.2 MEDIATION OF CHEMISTRY CONTENT.

4.2.1The CoRe

PCK constitutes a combination of pedagogy and content and using this for instruction. Bishop and Denley (2007) recognised that the professional knowledge of

[4] These Learning Outcomes are specific to all three textbooks.

a 'highly accomplished science teacher' not just in terms of possessing the knowledge but also by the capacity to use the knowledge to connect with the learners. The authors of the textbook are designing effective ways to impart knowledge to learners. The textbook is an expression of educational ideas and planned learning.

Loughran et al (2004) used a CoRe to capture and portray PCK from expert teachers. The CoRe in this study was used to try to identify the PCK of the authors.

A CoRe was developed for the unit, to try to illustrate how the authors of the textbook mediated the organic chemistry content for teaching and learning. Four different Big Ideas were identified as shown below. These ideas were established by trying to identify what the authors had seen as important in the development of this chapter. The four ideas that were determined are the major or central themes of this unit.

- Carbon is unique in its ability to form chains and rings.
- There are multiple ways of representing organic substances which are named using a standard system of naming. [IUPAC]
- Organic compounds show distinctive physical properties.
- Organic reactions depend on the distinctive chemical properties of organic molecules.
- The chapter covers a fairly small set of ideas that have a significant impact on learning and the CoRe attempts to cover all the critical aspects and features of the chapter. The CoRe for this textbook containing the four big ideas is shown below in Tables 4.2 and 4.3 below. It is an overview of the content to be taught, how it is to be taught and the reasons why it should be taught.

Table 4.2 The CoRe- Study & Master Physical Sciences Big Ideas 1&2

BIG IDEA/ PROMPTS	CARBON IS UNIQUE IN ITS ABILITY TO FORM CHAINS AND RINGS.	THERE ARE MULTIPLE WAYS OF REPRESENTING ORGANIC SUBSTANCES WHICH ARE NAMED USING A STANDARD SYSTEM OF NAMING. [IUPAC]
1 What do you intend your learners to learn about this idea?	Carbon is unique; single, double and triple bonds; molecular chains and rings; large variety of organic compounds; applications; history of organic chemistry; classification of aromatic and aliphatic compounds; types of formulae- molecular, structural (condensed), skeletal, three dimensional; different functional groups, saturated, unsaturated, homologous series and functional groups	Naming organic compounds-prefix, parent and suffix (what functional groups, number of carbon atoms and functional group) Basic IUPAC rules for naming and numbering alkyl and other substituent groups Understanding isomers
2 Why is it important for the learners to know this?	Understand different ways of writing and representing organic compounds Recognize functional groups in organic compounds	Use the IUPAC system for naming organic compounds Identify and name structural isomers Know, identify and name all of the members of a homologous series of organic compounds
3 What else do you know that the learners do not need to know yet?	Naming organic compounds; properties and uses of organic compounds; understanding reactions of organic compounds; organic macromolecules- polymerization. Biological macromolecules etc,	Properties and uses of organic compounds; understanding reactions of organic compounds; organic macromolecules- polymerization. Biological macromolecules etc,
4 Difficulties/limitations connected with teaching this idea?	Large amount of content and detail	Large amount of content to learn
5 Knowledge about the learners thinking which might influence your teaching of this idea?		Numbering and naming correctly Finding the longest carbon chain Recognizing functional groups
6 Teaching procedures and reasons for using these to engage the idea?	Pictures (p209) – organic compounds very different from inorganic compounds; Mind Map (210) classification of aliphatic and aromatic compounds Examples of all different types of formulae and representations (210, 211……..) Table (212) homologous series, structure of functional group, examples, condensed structures, name ending 3-D structures- (211);Ball and stick diagrams (217,219, 220, 223,) Text box – important information (212) Bold headings of sub-topics (210….)	Tables (212; 214) Homologous series/functional group/ name ending- Parent name and number of carbons Diagram (213) prefix, parent, suffix (214) finding the longest chain Examples 1 and 2 –naming (216, 216) Use of structural formulae with names (216….) Examples of isomers (structure) and names (217) Ball and stick diagrams.(217) Activity 16- in chapter exercise –questions on naming etc…

Table 4.3 The CoRe- Study & Master Physical Sciences Big Ideas 3&4

BIG IDEA/ PROMPTS	ORGANIC COMPOUNDS SHOW DISTINCTIVE PHYSICAL AND CHEMICAL PROPERTIES.	ORGANIC REACTIONS DEPEND ON THE DISTINCTIVE PHYSICAL AND CHEMICAL PROPERTIES OF ORGANIC MOLECULES TO DETERMINE THE TYPES OF REACTIONS THAT THEY UNDERGO.
1. What do you intend your learners to learn about this idea?	Melting and boiling points; length of chains Increasing chain length- van der Waal's forces; double and triple bonds- saturated and unsaturated; how functional group determines the nature of the compound; Uses: plastics, latex; sat. and unsat.bonds in oils and fats; fuels and combustion; volatility of Haloalkanes; Haloalkanes in polymers, CFCs-propellants and refrigerants; polarity of alcohol, formation of hydrogen bonds in alcohols in relation to boiling and melting points, alcohols in beverages and industry, ethers as anaesthetics; uses of other functional groups.	Organic compounds can undergo acid/base; redox, combustion, substitution, addition and elimination reactions; fermentation of glucose; addition (alkenes and alkynes) –hydrogenation and halogenations, polymerization;-addition on both sides of double or triple bond; addition of hydrogen halides (steam); acid/base-reaction of weak carboxylic acids (ethanoic) to hydronium ion and ethanoate ion; amides produced in reactions between amine and carboxylic acid; elimination involving alcohol to alkene and alkane to alkene and hydrogen; esterification-carboxylic acid and alcohol
2. Why is it important for the learners to know this?	To understand how and why organic reactions occur. Economic importance and variety of everyday examples	Identify and write balanced chemical equations for reactions of organic compounds
3. What else do you know that the learners do not need to know yet?	Understanding reactions of organic compounds; organic macromolecules- polymerization. Biological macromolecules etc,	Organic macromolecules- polymerization. Biological macromolecules etc,
4. Difficulties/limitations connected with teaching this idea?	Large amount of content	Difficulties in recognizing different type of reaction; Large amount of information on reaction conditions
5. Knowledge about the learners thinking which might influence your teaching of this idea?	Use of tables and picture to engage the learners' interest	Practical activities are important.
6. Teaching procedures and reasons for using these to engage the idea?	Tables (218, 220) –boiling and melting points/ molecular structure;(226) Different esters- smell and flavour Activity 16- in chapter exercise question 7 –properties of organic substances;Did you know- information on latex from rubber trees; aroma of oranges, vanilla….. In text content; Pictures- rubber tree, oxyacetylene torch, fruits	Practical activities help learners understanding-addition, substitution and esterification; Activity 19-in chapter exercise-applying organic reactions (implication that two products could form) Examples of various reactions; Acid/base reaction-Did you know- lemon masks fish smell in an acid/base reaction; Did you know?- radical substitution ;Example of Nucleophilic substitution

4.2.2 BIG IDEA 1: CARBON IS UNIQUE IN ITS ABILITY TO FORM CHAINS AND RINGS

In the first Big Idea which includes the concepts of understanding what organic chemistry is; classification of organic compounds and the introduction of the idea of functional groups and different structures, the authors expected that the learners would already know the work covered in grade 11 chemical change and chemical systems; types of reactions i.e. redox; acid/base as well as substitution, addition and elimination. Their intention was to convey to the learners that carbon is a unique element, present in many different compounds, whose atoms can form chains and rings by forming single, double and triple bonds to create molecules. In view of the many different types of molecules, classification is necessary to make meaning of functional groups; formulae, etc.

The authors showed the importance of understanding different ways of writing and representing organic compounds by showing the learners a variety of ways of doing this. I believe that the difficulty associated with teaching this idea is the large amount of content and detail. The teaching procedures used by the authors to engage this idea for example were:

- Pictures (pg 209) trying to show the difference between plants which contain carbon and hydrogen and the soil.
- A mind map showing the classification of aromatic and aliphatic compounds (Figure 4.6) .
- Many examples of formulae and molecular representations including 3-D structures, ball and stick diagrams (pg 211,217,223) etc.
- Tables showing homologous series, structures of functional groups (pg 212, 213).
- A text box was used on (pg 212) for the definition of a homologous series.
- Bold headings were used to indicate sub-topics.

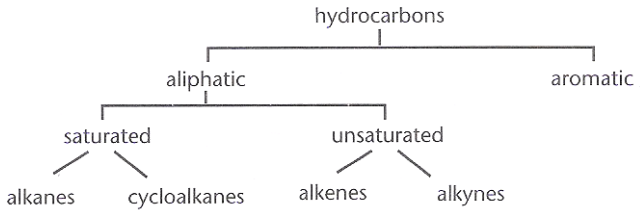


Figure 4.6: Classification of organic compounds

Because organic molecules are so structurally varied it is very important that the learners understand how they classified. Figure 4.6 shows how the aliphatic hydrocarbons are subdivided according to their state of saturation as well as whether they are found in straight chains, chains that contain branches or non aromatic rings (cyclic)[5]. Aromatic compounds, on the other hand, are cyclic molecules with conjugated double bonds. The understanding of these concepts is central to their understanding of organic chemistry.

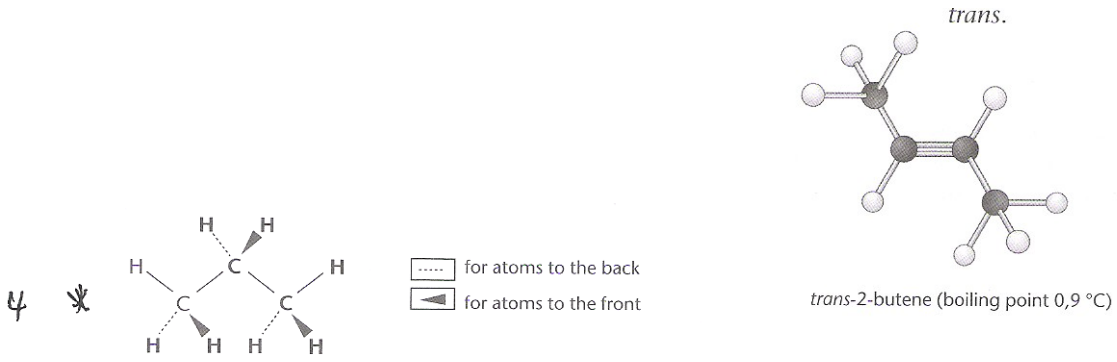


Figure 4.7: Three dimensional structures

The kind of representation in Figure 4.7: Three dimensional structures give the learners an idea of the three dimensional nature of the shape of the molecule. Having two different types of representation alongside each other shows the authors are aware of a need for learners to understand different types of representations. This in turn helps the learner understand concepts such as intermolecular forces, isomerism and reaction pathways.

[5] In chemistry, a cyclic compound is a molecule in which a series of atoms is connected to form a loop or ring. Cyclic compounds may or may not be aromatic. Benzene is a well known example of an aromatic compound

In a homologous series, all the molecules have the same functional group, but different lengths of carbon chains.

Figure 4.8: Text box containing highlighted information

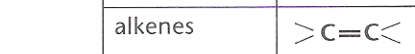
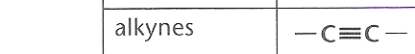
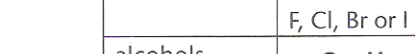
Homologous series	Structure of functional group	Name of example	Condensed structural formula of example	Name ending
alkanes		ethane	CH_3CH_3	-ane
alkenes		ethene	$CH_2{=}CH_2$	-ene
alkynes		ethyne	$CH{\equiv}CH$	-yne
haloalkanes	—X where X is F, Cl, Br or I	chloromethane	CH_3Cl	
alcohols		ethanol	CH_3CH_2OH	-ol

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Figure 4.9: Table of homologous series[67]

It is very important for the learners to understand that a homologous series (Figure 4.8 & Figure 4.9) is a series of compounds with the same general formula, similar chemical properties and a gradation of physical properties with increasing molecular mass. This means that the strength of intermolecular forces and therefore boiling and melting point depends on molecular mass and size. Knowing the general formula helps learners recognize the homologous series to which a compound belongs. Learning organic chemistry becomes easier for the learners when they realize that their study is limited to a few series of homologues.

4.2.3 BIG IDEA 2: THERE ARE MULTIPLE WAYS OF REPRESENTING ORGANIC SUBSTANCES WHICH ARE NAMED USING A STANDARD SYSTEM OF NAMING. [IUPAC]

In the second Big Idea which involves naming of organic compounds the authors intended the learners to understand about naming organic compounds (Figure 4.10) using the ideas of prefixes, parent chains and suffixes and applying the basic IUPAC

[6] An alkyl group or branch is considered to be a functional group not the alkane chain itself and thus this is an error in the textbook.
[7] Name ending in table should refer to both prefixes and suffixes.

rules for naming and numbering alkyl and other substituent groups. The concept of isomers was also covered in this section. The authors' PCK was evident; by showing the learners how to number and name correctly, how to find the longest carbon chain and how to recognize functional groups.

The teaching procedures used by the authors involved:

- The use of tables to show homologous series, functional group and name ending, parent name and number of carbons (Figure 4.10).
- Diagrams showing prefix, parent and suffix (pg 213)
- Examples of naming (pg 216, 216)
- Use of structural formula together with the names (pg 216)
- Examples of isomers and names (pg 217)
- Ball and stick diagrams (pg 217)
- An in- chapter exercise which contained questions on naming.

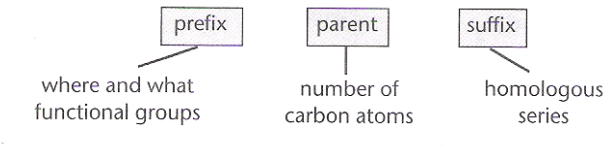


Figure 4.10: Naming of organic compounds

The learners need to understand the need for an organised naming system as the number of different organic compounds is increasing on a daily basis and many of these are isomers of each other so each compound must be given a distinctive name. The IUPAC naming system is a set of logical rules devised to overcome these problems. The diagram in Figure 4.10 helps the learners to understand this concept.

4.2.4 BIG IDEA 3: ORGANIC COMPOUNDS SHOW DISTINCTIVE PHYSICAL AND CHEMICAL PROPERTIES.

The third Big Idea involves the properties and uses of organic compounds and the authors deal with melting and boiling points linking it to chain length. They link the increasing chain length with van der Waals forces and show how the functional group in the molecule determines the nature of the compound. They indicate uses

for plastics; latex; saturated and unsaturated bonds in oils and fats, fuels and combustion and mention volatility of halkoalkanes etc. It is important for the learners to know this so that they can understand organic reactions as well as see the economic importance of these reactions as well as the variety of everyday examples. The authors have used tables and pictures to engage the learner's interest in this big idea. Examples of these are tables pg 218+220 (Figure 4.11 & Figure 4.12) and "Did you know "text" box of information pg 226.

Alkane	Molecular formula	Melting point (°C)	Boiling point (°C)	Phase at room temperature
methane	CH_4	–183	–162	gas
ethane	C_2H_6	–183	–89	gas
propane	C_3H_8	–190	–42	gas
butane	C_4H_{10}	–138	0	gas
pentane	C_5H_{12}	–130	36	liquid
hexane	C_6H_{14}	–95	69	liquid
heptane	C_7H_{16}	–91	99	liquid
octane	C_8H_{18}	–57	126	liquid
nonane	C_9H_{20}	–54	151	liquid
decane	$C_{10}H_{22}$	–30	174	liquid
undecane	$C_{11}H_{24}$	–25	196	liquid
dodecane	$C_{12}H_{26}$	–10	216	liquid
eicosane	$C_{20}H_{42}$	37	344	solid
triacontane	$C_{30}H_{62}$	66	450	solid

Figure 4.11: Table showing molecular formula, melting point, boiling point and phase at room temperature.

Ester	Smell or flavour
Ethyl-2-methyl butanoate	apple
3-methylbutyl ethanoate	pear
Butyl butanoate	pineapple
Octyl ethanoate	orange
Methylpropyl methanoate	raspberry
Pentyl butanoate	strawberry

Figure 4.12: Smell or flavour of different esters[8]

[8] Error in the name of the apple flavour which should read ethyl 2-methylbutanoate

4.2.5 BIG IDEA 4: ORGANIC REACTIONS DEPEND ON THE DISTINCTIVE PHYSICAL AND CHEMICAL PROPERTIES OF ORGANIC MOLECULES TO DETERMINE THE TYPES OF REACTIONS THAT THEY UNDERGO.

The fourth Big Idea involves the learners understanding the chemical reactions of organic compounds. The authors intended the learners to understand that organic compounds can undergo acid/base, redox, combustion, esterification (Figure 4.), addition, substitution and elimination reactions. These reactions could include fermentation of glucose and hydrogenation, halogenations; polymerization etc. The difficulties associated with this idea are abilities of the learners being able to recognize the various reactions as well as the large amount of information on reaction conditions which the learners would have to rote learn. The authors understand that practical activities are important. The chapter includes two practical activities the first being the addition and substitution reactions of the alkanes and alkenes and the second being the preparation of an ester. Both of these activities focus on LO1. Activity 17 (pg 233) asks the learners to design an experiment to investigate the differences between alkanes and alkenes whereas Activity 18 (Figure 4.13) is a recipe type practical for the preparation of an ester. Also included are examples of various reaction types, “Did you know information” text boxes on radical substitution and a note on nucleophilic substitution is given.

WORK IN GROUPS

Activity 18: Preparing an ester

LO1: AS1, AS2, AS3

Note: Many organic compounds are flammable and should not be left near an open flame.

You will need

- large test tubes
- Bunsen burner
- water bath
- beaker with water
- ethanol
- ethanoic acid (glacial acetic acid)
- concentrated sulphuric acid
- fragments of porcelain or boiling stones

1. Pour 3 ml ethanol, 1 ml concentrated sulphuric acid and 4 ml ethanoic acid into a test tube. Add the boiling stones.
2. Heat in the water bath for a few minutes. The temperature of the water bath should not exceed 85 °C. The reaction is completed when the froth disappears.
3. Pour the contents onto water in a beaker. Smell the ester that should float on the water.
4. Using structural formulae, write a balanced equation for the reaction.
5. Why is sulphuric acid added to the reaction mixture?
6. Other esters that can be synthesised are shown in the table.

Note: To smell a chemical safely, wave your hand across the beaker towards your nose and sniff cautiously.

Alcohol	Carboxylic acid	Ester	Flavour
ethanol	methanoic acid		rum
	ethanoic acid	pentyl ethanoate	banana
butanol	butanoic acid		pineapple
ethanol		ethyl butanoate	apricot

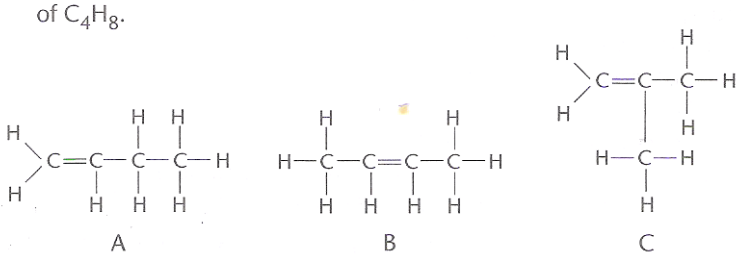
Figure 4.13: Activity on preparing an ester[9]

[9] Not all esters are miscible with water and remain in a separate layer.

Activity 19: Applying organic reactions

LO1: AS3, AS4; LO2: AS1, AS2

1. Propane gas is mixed with chlorine gas. The mixture is left in the sun for a while.
   a) Write a balanced equation for the reaction by using structural formulae.
   b) Name the type of reaction that took place.
   c) What will happen if the reaction mixture is not placed in the sun?
2. 1-bromopropane is dissolved in ethanol. The solution is allowed to react with (i) sodium hydroxide and (ii) ammonia.
   a) Write balanced equations (use condensed structural formulae) for the reactions that occur in (i) and (ii).
   b) What is this type of reaction called?
   c) Give the names of the organic products that form.
3. The following diagrams show the structures of the three isomers of C_4H_8.



A B C

   a) To which homologous series do the three isomers belong?
   b) Compound A reacts with bromine.
      i) Draw the full structural formula of the product and give its IUPAC name.
      ii) What type of reaction has taken place?
      iii) What do you observe during the reaction?
   c) Compound B is mixed with hydrogen gas and passed over a Pd-catalyst.
      i) Draw the full structural formula of the product and give its IUPAC name.
      ii) What is this type of reaction called?
      iii) How is this reaction used in industry?
   d) Compound C is reacted with steam in the presence of phosphoric acid.
      i) Name the type of reaction that occurs.

Figure 4.14: Assessment task on applying organic reactions

4.2.6 ANALYSIS OF PCK

The data obtained in the CoRe (Table 4.2 and 4.4) and the analysis of the textbook was coded using the categories from the adaptation of the Bishop and Denley

"Spinning Top" model (2007) (Figure 4.15) and this was then compared to the examination guidelines for 2009/2010/2011 (Education, 2010).

Examples from each of these six knowledge categories are described below.

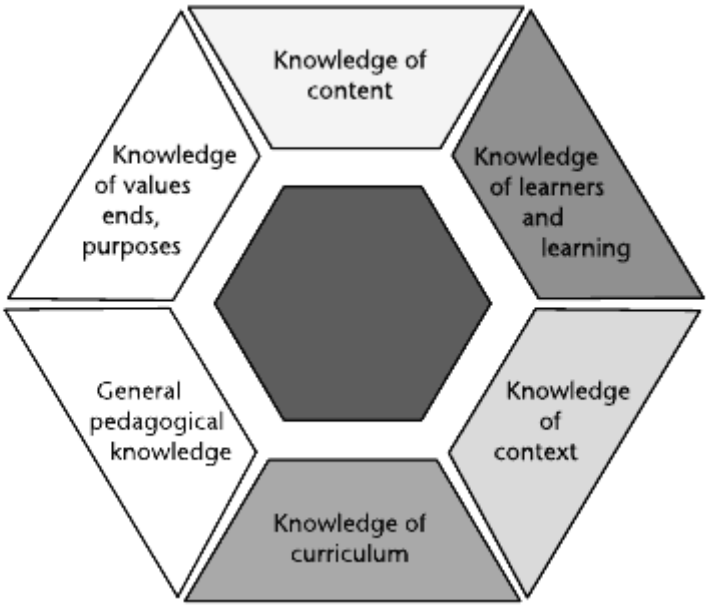


Figure 4.15 Spinning Top Model (Bishop & Denley, 2007)

4.2.7 KNOWLEDGE OF THE CURRICULUM

The authors demonstrated knowledge of the curriculum throughout the chapter for example:

- Key concepts (pg 209) (Figure 4.2)
- Background to carbon chemistry (pg 209)
- Classification of hydrocarbons (pg 210)
- Types of formulae (pg 210+ 211)
- Functional groups (pg 212)
- Basic rules for naming hydrocarbons (pg 214)

However this knowledge of the curriculum did not always coincide with the examination guidelines. The examination guidelines were used as the "curriculum" document as this is the actual material that grade 12 learners are examined on. It

must be pointed out that this does not coincide with what was originally planned, or what the teachers deliver to their group of learners or what the learners experience in their specific classrooms. The textbook authors had no prior knowledge about what changes would be made and cannot be responsible for changes made after the implementation of the new curriculum. However, this is the one document that helps teachers decide on what to teach as the Department of Education /Examiners have changed these guidelines every year since 2008. The textbook is an expression of the course of study and should contain more than just content that is examinable and in this case it fails to cover all of the examinable content. In this textbook there is a failure by the authors to include adequate exercises for problem solving and critical thinking, as well as a failure to include some important content relating to the examination guidelines. The information that is missing is shown in the table below.

Table 4.4 Missing information in textbooks

MAIN TOPICS OF DOE EXAMINATION GUIDELINES 2009	STUDY AND MASTER PHYSICAL SCIENCES INFORMATION MISSING FROM CONTENT
Organic molecular structures-functional groups, saturated and unsaturated structures, isomers, systematic naming and formulae	Naming of cyclo-alkanes with or without alkyl substituent groups. Naming of alkenes with alkyl substituent groups. Isolated and cumulated dienes Naming of alkynes with alkyl substituent groups. Naming of halo-alkanes, cyclic haloalkanes Primary, secondary and tertiary alcohols, alkyl substituents Branched carboxylic acids. Primary, secondary and tertiary amines N and N,N in naming of amines. Naming of aldehydes with substituent groups Naming of ketones with substituent groups Arenes- alkyl substituents
Structure and physical property relationships	Vapour pressure Viscosity
Substitution, addition and elimination reactions	Hydro-halogenation & reaction conditions H atom attaches to carbon atom with the greater number of H atoms; X atom attaches to the more substituted C atom. Hydration-reaction conditions, position of attachment of OH group Substitution reactions-primary, secondary and tertiary alcohols

The Key concepts listed in Figure 4.2 p 31 show that the authors based the chapter on the curriculum.

4.2.8 KNOWLEDGE OF THE CONTENT

The aim of teaching science is to enhance the understanding of the learners and therefore the authors need to show a flexible and comprehensive understanding of the subject matter that they are presenting. This means that the authors should be able to represent and formulate the material in a manner which is comprehensible to the learners.

There are numerous examples throughout the chapter showing authors' knowledge of content. No obvious errors were found in the text. Some examples of the authors' knowledge of the content are:

- The diagrams of structural formulae (pg 214 and 216 ;)
- Table for naming hydrocarbons (pg 214)

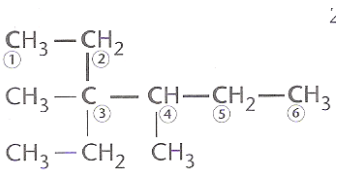


Figure 4.16: Naming of organic compounds

4.2.9 KNOWLEDGE OF THE CONTEXT.

There is evidence in the chapter of knowledge of the context from which the content is taken. Examples of these are the picture of welding (pg 221) (Figure 4.18) and the fermentation of wine in a wine cellar on (pg 222).

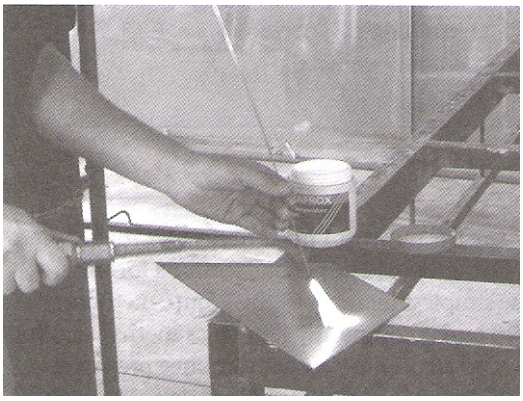


Figure 4.17: Welding with an oxy-acetylene torch

However, there is also evidence of knowledge of the learners' context for example on page 221(Figure 4.9) where description of alkenes and alkynes are in textboxes to highlight the importance of the information and provide the learners with easy access to the information.

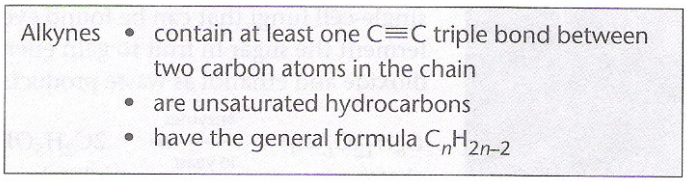


Figure 4.18: Description of alkynes

The learners are active participants in the learning process and their needs should be considered by the authors. This textbook has no glossary; no end of chapter answers or summaries to fulfil some of the learners needs. The authors have included some worked examples to help the learners while they are studying on their own. Common errors made by learners are not covered in either the textbook or the Teachers' Guide. Learners could benefit from information about successful learning paths. There is also little evidence of the needs of second language learners being taken into account by the authors.

4.2.10 KNOWLEDGE OF VALUES, ENDS AND PURPOSES

There is evidence in the chapter of knowledge of values, ends and purposes. An example of this is in the Key Concepts given on page 209 where the authors show the learners where the information in this chapter is leading them. Other examples of this are found in for example the definitions of alkenes and alkynes found on pg 220 and the "Did you know?' (pg 220). Subject matter knowledge has to include opportunities for the learners to re-examine the subject matter content for themselves and the authors have included a summative assessment activity for the learners to do alone covering important aspects included in the chapter on page 236.

4.2.11 KNOWLEDGE OF LEARNERS AND LEARNING

Evidence was found in the chapter that the authors of the textbook had knowledge of learners and learning. An example of this is to be found in the textbox (page 212) where a definition of homologous series is given. This is easily accessible to learners while studying for tests and examination and highlighted for easy reference.

Another example is in the background to carbon chemistry (pg 209). The authors are aware that although the learners have learned about carbon in previous grades revision of this knowledge is essential e.g. atomic number, valency, ability of carbon atoms to form four bonds, ability of carbon atoms to form long chains, uniqueness of carbon etc. However there is very little information or reinforcement of prior knowledge given in this chapter on intermolecular forces which learners find very difficult to understand and apply to new situations. There is also not any mention or evidence of learners misconceptions.

A third example can be found on pages 212 and 213 where the table of organic functional groups allows the learner to access information easily without necessarily reading through all the text. A fourth example can be found (pg 216) (Figure 4.20) where a solution to an example problem is clearly shown.

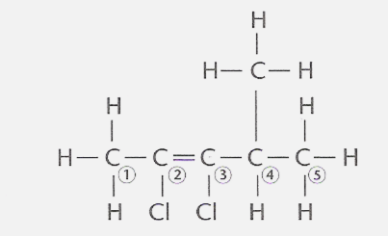


Figure 4.19: Example of solution to question on drawing a structural formula

4.2.12 GENERAL PEDAGOGICAL KNOWLEDGE

The authors also demonstrate general pedagogical knowledge in the general layout of the information and the activities that have been included in this unit. This refers to the way in which the material is presented to the learners by the authors in a systematic and logical manner. Examples of this can be found in the manner in which the authors indicate how the activities should be completed and the order in which they should be completed. For example the practical work on preparing an ester (Figure 4.13) comes after the explanation for elimination reactions and esterification.

4.3 OVERVIEW OF THE CHAPTER

A general description of the book and the mediation of the chemistry content are described in this chapter of Study and Master Physical Sciences, which was published by Cambridge University Press in 2007 for the new curriculum.

The book is the smallest of the three books analysed. The section on organic chemistry is consistent with the rest of the book but only about 16.6% of the book is dedicated to one sixth of the total examinable content.

The sequence of the chapters is logical and the chapter contains clear signposts and instructions. The chapter does not contain a summary but at the start of the chapter the key concepts are listed. The format of the book is visually appealing and interesting and the information is presented in a variety of ways. The text however, gives an appearance of being dense and difficult to read. The reading level is age appropriate for grade 12 but may be difficult for second language learners.

The book includes a section to help the learners to use the book and the teacher's guide provides reproducible assessments for different types of tasks. Answers to the various activities are only in the teacher's guide so the learners do not have access to answers to the activities during self study. Learning Outcomes are given at the start of every activity. No extra information is given on how to teach the section or what the learners' misconceptions and prior conceptions might be. There is also a lack of activities on Learning Outcome 3.

The analysis of the mediation of the chemistry content begins with the big ideas extracted from the text in the form of the CoRe. Examples from the text have been selected to illustrate these ideas. A CoRe was developed for the unit, to try to illustrate how the authors of the textbook mediated the organic chemistry content for teaching and learning. Four different Big Ideas were identified. These ideas were established by trying to identify what the authors had seen as important in the development of this chapter. The four ideas that were determined are the major or central themes of this unit.

Each of the knowledge bases from Bishop and Denley's model have been described together with relevant examples from the text in an attempt to identify the PCK of the authors.

The section on intermolecular forces is covered in grades 10 and 11 but is usually asked in the grade 12 examination with reference to boiling and melting points of different compounds. There is not sufficient information on intermolecular forces given in this chapter for grade 12 learners.

In my experience learners also struggle with the concept of isomerism. This textbook does show the learners that isomers can come from different functional groups. There is an example given on pg 217 of alcohols being structural isomers of ethers. A text box on the same page highlights the importance of the same molecular formula but a different structural formula. I believe the authors could have highlighted this as a potential difficulty for learners in the Teacher's Guide. In a question on isomerism in Activity 16 the learners are asked to draw and name isomers of c_6H_{10}. I think that a more challenging question could have been asked, for example asking whether carboxylic acids and esters could be isomers.

As a teacher I feel that some of these concepts are very important to teach to the learners regardless of whether or not they are in the examination guidelines. An example of this from the above list is that of a general formula. This can help the learners identify the functional group as well as allow them to correctly write down a molecular formula for a compound. I usually only teach the general formulae for alkanes, alkenes and alkynes and this is usually sufficient to answer question that for example asks the learners to write down a combustion reaction.

Although the authors have shown PCK in all areas of Bishop and Denley's model, there is a lack of attention paid to learning outcome three as well as to the variety of different activities for the learners to engage with meaningfully. Further research could be done on whether the complexity of the tasks is on the correct level for grade 12 learners. The purpose of learning requires learners to practice in order to gain expertise and mastery over the content. In this textbook the activities seem to be limited. The issues which must be considered in order to develop valuable instruction include an in depth knowledge of the learners and their needs, the material to be learned or content, the goals and outcomes that are required and the learning strategies to engage the learners' interest in line with these goals. These strategies should assist the learner in developing intellectual tools to integrate and accommodate the new information.

Recall activities are only useful for simple concepts. The learners need to use and interact with the content in everyday situations which ensures better understanding of the content.

In the next chapter the textbook 'Focus on Physical Sciences' and how the authors have mediated the organic chemistry content, is described.

CHAPTER 5 FOCUS ON PHYSICAL SCIENCES

5.1 INTRODUCTION

In this chapter the textbook 'Focus on Physical Sciences' and how the authors have mediated the organic chemistry content, is described.

The cover and essential details are shown in Table 5.1 and Figure 5.1.

Table 5.1 Details of textbook Focus on Physical Sciences

Authors	Hendricks, Sadeck, Spies
ISBN Number	9780636078659
Publisher	MASKEW MILLER LONGMAN
Grade	12
Series	FOCUS
Year	2007

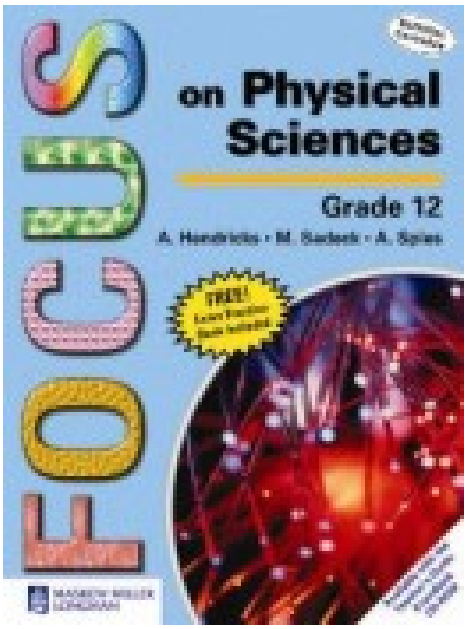


Figure 5.1 Cover-Focus on Physical Sciences

The textbook was first published by Maskew Miller Longman (Pty) Ltd in 2007 (Table 5.1 & Figure 5.1).The learners' pack includes the learners' book and an examination practice book. The educators' pack includes the Teacher's Guide as well as an Exam Bank CD-ROM (Figure 5.2). According to the publishers 'Maskew Miller Longman's Grade 10-12 range features Learner's Books, Teacher's Guides, Work

Books, Exam Practice Books and Exam Bank CD-ROMs, all specially developed for the new curriculum' (Figure 5.2).

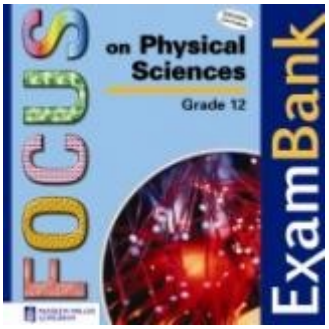


Figure 5.2: Focus on Physical Sciences Exam Bank

The Exam Bank is a databank of questions and as questions are selected from the databank a question paper and suggested memorandum is generated. This is very useful for teachers for setting worksheet, tests and examinations.

FOCUS

Focus / *Verken* is the only course that offers a complete solution for teaching excellence and exam success!

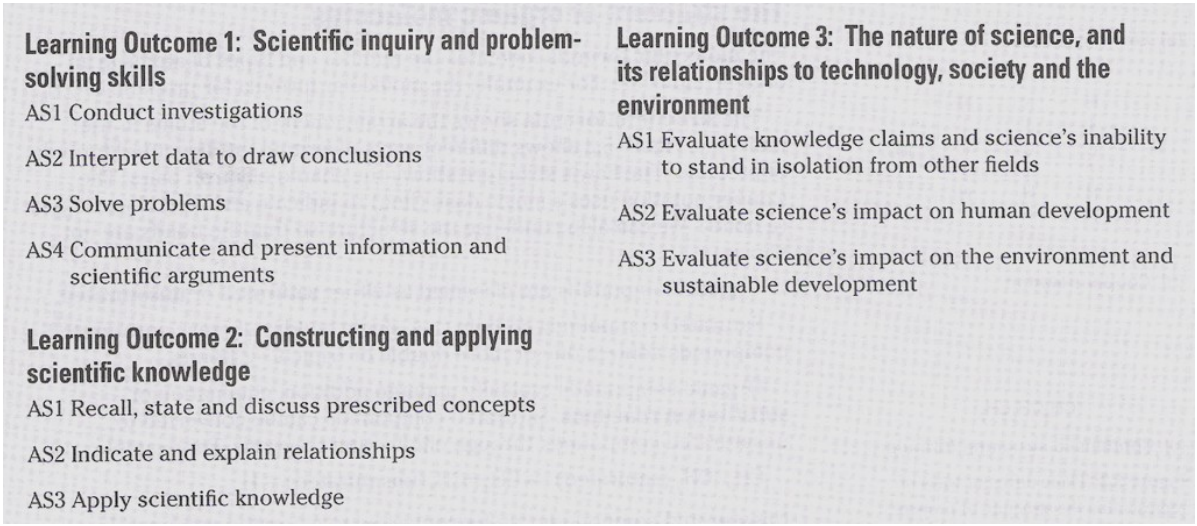
- Covers the latest content
- Provides teachers with a complete assessment solution
- Is written on the level of the learner
- Uses relevant South African examples and is easy to use

Figure 5.3: Description of the Focus Series

(Maskew Miller Longman Educational Publishers)

5.1.1 THE LEARNER'S BOOK

The textbook is 22cm by 28cm and is larger than the Study and Master Physical Sciences but smaller than Physical Sciences Explained. The section on organic chemistry is found in chapter 5 in the section on Matter and Materials II. It consists of 16 pages (page 152 -168) and includes content, diagrams, tables, pictures and in chapter activities. A summative assessment on the whole chapter is also included at the end of the section (pg 188) as well as a summary of key concepts (pg 191). The chapter also includes sections on organic macromolecules and biological macromolecules which are not included in this study. The layout of the chapter is consistent with the other chapters within the book. The chapter is introduced with a mind map of the three main areas of content covered in the chapter. All three learning outcomes and the assessment standards used by the authors within the chapter are listed (Figure 5.4).



Learning Outcome 1: Scientific inquiry and problem-solving skills

AS1 Conduct investigations

AS2 Interpret data to draw conclusions

AS3 Solve problems

AS4 Communicate and present information and scientific arguments

Learning Outcome 2: Constructing and applying scientific knowledge

AS1 Recall, state and discuss prescribed concepts

AS2 Indicate and explain relationships

AS3 Apply scientific knowledge

Learning Outcome 3: The nature of science, and its relationships to technology, society and the environment

AS1 Evaluate knowledge claims and science's inability to stand in isolation from other fields

AS2 Evaluate science's impact on human development

AS3 Evaluate science's impact on the environment and sustainable development

Figure 5.4: Learning Outcomes and Assessment Standards pg151

The textbook covers grade12 work only and is divided into seven chapters:

- Mechanics
- Waves, sound and light
- Electricity and magnetism
- Matter and materials I
    - Mechanical Properties of materials
    - Optical properties of materials

- Matter and materials II
    - Organic molecules
    - Organic macromolecules
    - Biological macromolecules
- Chemical change
- Chemical systems

At the beginning of the book the authors explain the new approach to education adopted in South Africa and knowledge of values, ends and purposes are emphasized. They also indicate what the features of the book are, for example each chapter begins with a mind map (Figure 5.5) so that the learners can see what content is covered in the chapter and how it fits together as well as which learning outcomes and assessment standards are covered in the chapter. They indicate that the activities in the book which consist of both group and individual work are meant to help the learners discover and understand the content and to promote cooperative learning. The summative assessments are there to check understanding before moving to the next chapter. According to the authors the glossary at the end of the book is there to check the meanings of the important terms which are in bold in the text. (Found immediately after the contents page before page 1)

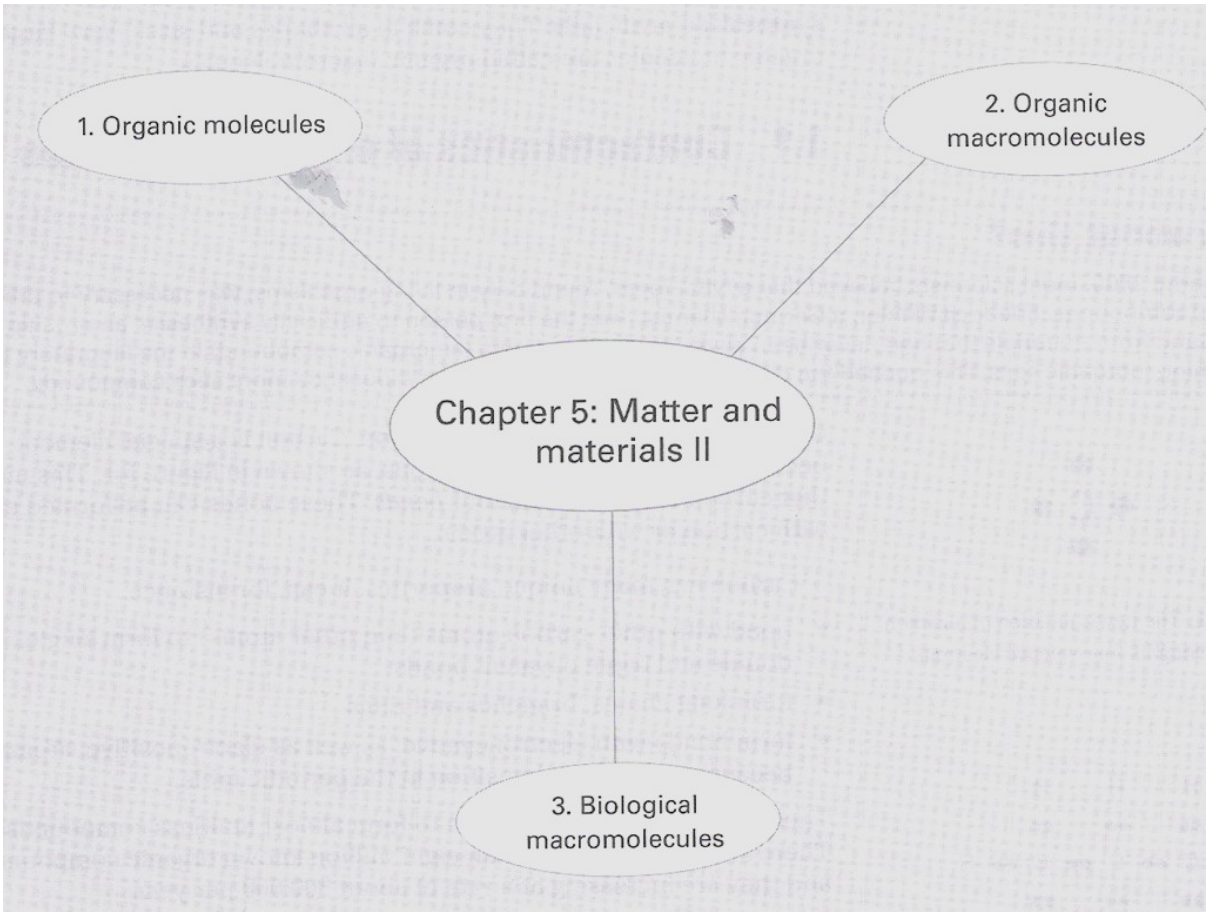


Figure 5.5: Mind Map Chapter 5 Focus on Physical Sciences pg 151

The book catalogues the contents at the front of the book but also has an index (Figure 5.7) at the back of the book together with a glossary (Figure 5.6), table of learning outcomes and assessment standards, units of measurement, constants and variables and a Periodic table.

structural formula a set of symbols that shows the arrangement of the atoms in a molecule, in addition to its chemical composition
structural isomers molecules that have the same molecular formula but different structural formulae; isomers differ in their physical and chemical properties
substitution reactions a chemical reaction, in which an atom or group is substituted (replaced) by other atoms or groups

Figure 5.6: Example of definitions from glossary page 274

Figure 5.7: Example from index Focus on Physical Sciences

The sequence of the chapters is logical and the chapter contains clear and comprehensive instructions or signposts. The authors use text boxes to highlight important or interesting information. Examples of this are the “How about this?” (Page 152) and the “Note” for rules to name organic compounds (Figure 5.8)

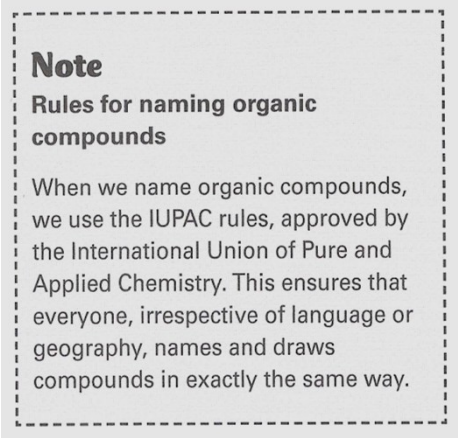


Figure 5.8: Note Rules for naming organic compounds page 153

The reading level of the chapter is appropriate for the level or grade being taught. I used two paragraphs chosen at random in the chapter and used the Flesch Kincaid Reading Ease Test contained within Microsoft Word 2007 to see if the reading level was appropriate. The grade level for this book is between 11.1 and 12, which is appropriate for grade 12. All important terms are in bold text and the explanations and definitions for these are contained in the glossary (Figure 5.6) at the end of the book.

The size of the print was checked using the Pica system described in chapter 4 on Study and Master Physical Sciences. The headings and text in this book ranged from +/- 11pt to +/- 14pt. The general guideline for printed text is to use between 11 and 14 point font regardless of the audience and this appears to be the most common size for print in most media.

The format of the book is visually appealing and interesting. The information is presented by the authors in many ways, for example, mind maps (Figure 5.9), activity for individuals as well as activities for groups (pg 154), text boxes (pg 152 and 153), tables (pg 153), chemical structures (pg 152), worked examples (pg 156), signposts (Figure 5.10) to other information in different chapters of the book (pg 158

and 159), pictures (pg161), diagrams (pg 162), case studies (pg 163), summative assessment (pg 188) and summary of key concepts (pg191). The authors have also included non-text content in the form of tables, structural formulae and pictures into the text which are accurate and well integrated into the text. These were all correctly and appropriately referenced to the text.

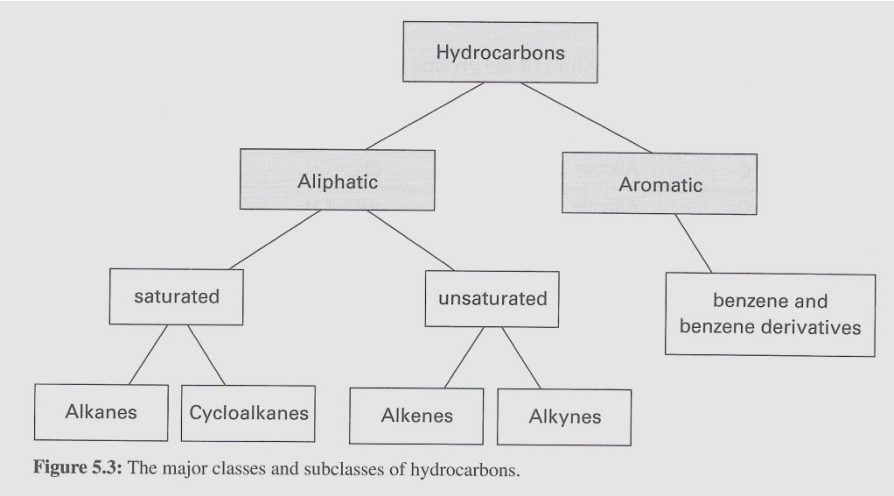


Figure 5.3: The major classes and subclasses of hydrocarbons.

Figure 5.9: Mind Map page 154

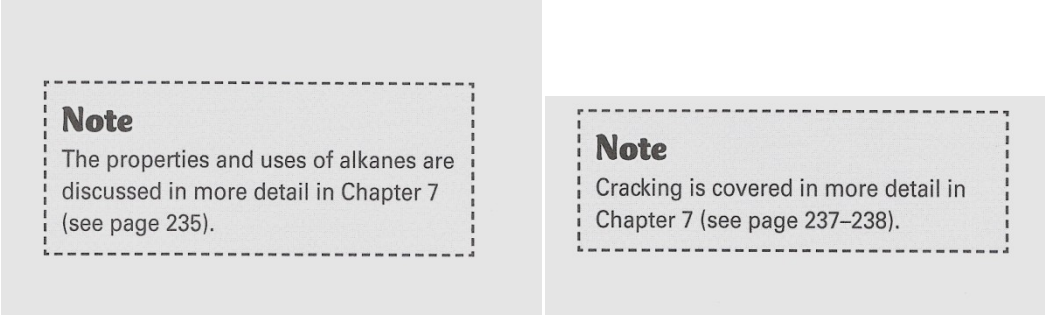


Figure 5.10: Signposts to information in another chapter

The authors have provided a selection of different types of activities together with some teaching guidelines for each. They indicate in the general guidelines for the chapter the importance of discerning patterns in organic chemistry and how the teacher should draw the learners' attention to the patterns in structures of functional groups. They also indicate the importance of providing the learners with opportunities to practise naming and drawing compounds and writing chemical reactions. This selection of activities and teaching guidelines gives an indication of the authors' PCK.

For example the teaching guideline for an activity which is suggested for individual work (pg 154) is to make sure that learners are aware that compounds with the same functional group will be named in the same way and will undergo the same type of reaction. The activity also provides the learners with cues and signposts on where they are likely to find help with the activity within the chapter e.g. “study the table of functional groups on the previous page”.

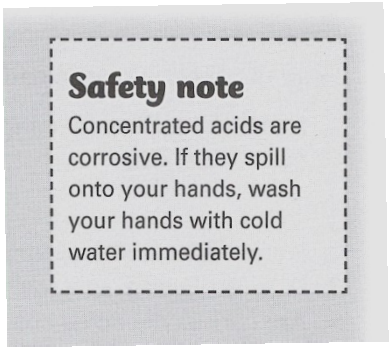
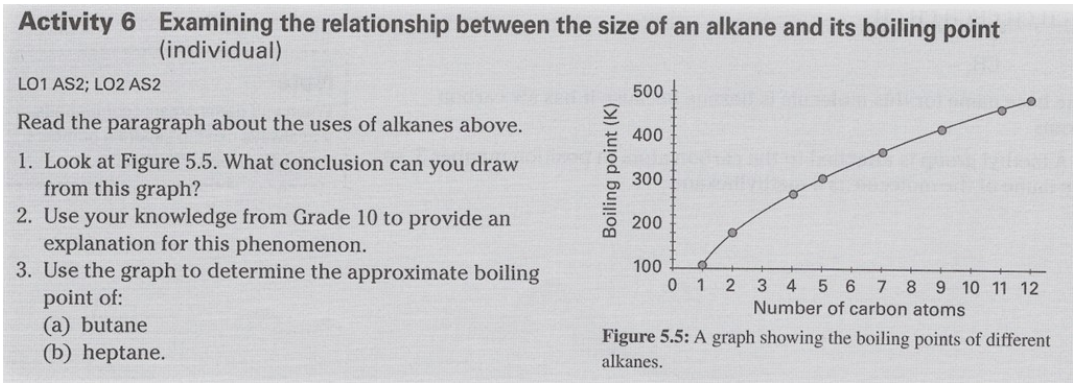


Figure 5.11: Example of a safety note

The chapter provides 16 activities for the learners to do and these include practical activities (Figure 5.113) (pg 154, 155 and 166), activities designed to allow the learners to practise the concepts they have learned such as naming and drawing alkanes (pg 158), activities devised to explore information provided such as the graph shown in activity 5.6 (pg158) where learners are asked to examine the relationship between the molecular size of an alkane and its boiling point (Figure 5.12), activities based on case studies (pg 163) where learners are shown how organic chemistry affects their daily lives and activities to help the learner study the content presented in the chapter (pg 169) where the learner is asked to draw up a table of examples, uses and properties of various functional groups of compounds.



Activity 6 **Examining the relationship between the size of an alkane and its boiling point** (individual)

LO1 AS2; LO2 AS2

Read the paragraph about the uses of alkanes above.

1. Look at Figure 5.5. What conclusion can you draw from this graph?
2. Use your knowledge from Grade 10 to provide an explanation for this phenomenon.
3. Use the graph to determine the approximate boiling point of:
   (a) butane
   (b) heptane.

Figure 5.5: A graph showing the boiling points of different alkanes.

Figure 5.12: Activity examining the relationship between the size of an alkane and its boiling point page 158

Learning outcomes and assessment standards are given at the beginning of each activity. All three of the learning outcomes and all of the assessment standards were used in the activities in this chapter.

5.1.2 THE TEACHER'S GUIDE

The Teacher's Guide follows a similar format being divided into the same seven chapters. It also includes sections on:

- How to use this book
- Introduction to the National Curriculum
  - What are the critical changes in the new curriculum for the FET?
  - Design features of the National Curriculum for FET
  - Example subject framework for FET Physical Sciences
  - Example work Schedule for FET Physical Sciences
  - Content and concept in Physical Sciences
  - Accommodating learners with special needs.
  - Resources
  - OBE and Assessment in FET
  - Subject assessment guidelines
  - Photo-copiable Assessment checklists and rubrics.

According to the publisher the Teacher's guide has been designed to assist the teacher with the planning and preparation of the Physical Sciences Grade 12 curriculum. The first section provides an overview of the National curriculum and

includes information for planning and assessment in the form of checklists and rubrics as well as suggested programmes for assessment, examples of works schedules and lesson plans.

The second section includes teaching guidelines for each of the seven chapters. The following is provided for each chapter:

- Teaching and learning focus which gives an overview of key concepts in each chapter.
- Learning outcomes and assessment standards covered in each chapter.
- Integration with other subjects (cross curricular links).
- Suggestions for remedial and enrichment teaching.

The following is provided for each activity within the chapter:

- Learning Outcomes and assessment standards.
- Detailed information on how to approach teaching the activity.
- Suggestions for how to assess the activity.

5.1.3 THE EXAM BANK CD ROM

The Exam Bank CD-ROM forms part of the Teacher's Guide and is a tool for setting tests, exercises and examinations with many possible variations available as it contains a large database of questions based on the National Curriculum. These questions are compiled as documents which can be edited, and the suggested solutions to the questions are automatically compiled with the questions by the program. The authors included both questions for section A (short questions) as well as for section B (longer questions) of the examination. Unfortunately, the Exam Bank is not compatible with Windows 7 and some of the question types included in the Exam Bank have been more recently excluded from the final examinations.

5.1.4 THE FET PRACTICALS BOOK

The FET Practicals Book is a work book to provide learners with support while carrying out practical investigation in grades 10, 11 and 12. It also includes assessment tools (Figure 5.13), suggestions, guidance for planning, designing, setting up and conducting practical investigations.

Observation checklist (complete while doing the practical work)

Assessment Criteria	Competence rating						
	1	2	3	4	5	6	7
CO2: Learner works well in the group and is able to help and support others.							
LO1: AS Solve problems: Learner is able to solve problems encountered in setting up and conducting the experiment.							
LO1: AS Conducting an investigation: Learner planned and drew flow chart for Part A correctly.							
LO1: AS Conducting an investigation: Learner planned and drew flow chart for Part B correctly.							
LO1: AS Conducting an investigation: Learner planned and drew flow chart for Part C correctly.							
LO1: AS Conducting an investigation: Learner is able to set up and handle apparatus confidently and correctly.							
LO1: AS Conducting an investigation: Learner is able to work safely.							

Figure 5.13: Observation Checklist for Organic chemistry practical in Practicals Book

Problem solving is essential for scientific inquiry. Scientific inquiry requires learners to use higher order thinking skills by encouraging them to ask questions, design investigations, investigate problems, formulate explanation, presenting and reflecting on findings. The authors have shown in this Practical Booklet that they are aware that practical inquiry needs to be approached in a different way to the ordinary subject content.

5.1.5 THE EXAM PRACTICE BOOK

The Exam Practice Book which comes together with the learners' textbook includes useful information to help learners prepare for examinations, worked examination papers which guide the learners through the papers by showing how the question should be approached as well as showing model answers and full practice examination papers.

5.2 MEDIATION OF CHEMISTRY CONTENT.

A CoRe was developed for the chapter, to try to identify how the authors of the textbook mediated the organic chemistry content for teaching and learning. Four different Big Ideas were identified. These ideas were established by trying to identify what the authors had seen as important in the development of this chapter. The four ideas that were chosen are the major or central themes of this unit. The chapter covers a fairly small set of ideas that have a significant impact on learning and the CoRe attempts to cover all the critical aspects and features of the chapter.

- Carbon is unique and has the ability to form chains and rings.
- There are multiple ways of representing organic substances which are named using a standard system of naming.
- Organic compounds show distinctive physical properties.
- Organic reactions depend on the distinctive chemical properties of organic molecules.

Table 5.2 CoRe Big Ideas 1&2

THE CoRe FOCUS ON PHYSICAL SCIENCE-MASKEW, MILLER, LONGMAN		
BIG IDEA/ PROMPTS	BIG IDEA 1 CARBON IS UNIQUE AND HAS THE ABILITY TO FORM CHAINS AND RINGS.	BIG IDEA 2 THERE ARE MULTIPLE WAYS OF REPRESENTING ORGANIC SUBSTANCES WHICH ARE NAMED USING A STANDARD SYSTEM (IUPAC) OF NAMING.
1 What do you intend your learners to learn about this idea?	Carbon is unique. Characteristic of organic molecules. Aliphatic and aromatic hydrocarbons. Functional groups as an arrangement of atoms. Concepts of saturated and unsaturated. - Test for un-saturation.	Lewis and Couper notation; condensed structures, full structures, molecular formulae, isomers, rules for naming and drawing.
2 Why is it important for the learners to know this?	To relate to the other topics in matter and material i.e. organic macromolecules and biological macromolecules. To be able to understand the other Big Ideas- naming and drawing; properties and uses and organic reactions	Structural isomers have the same molecular formulae but different structures Representations that look different may be the same compound..
3 What else do you know that the learners do not need to know yet?	Naming and drawing, properties and uses and reactions of organic compounds, organic macromolecules and biological macromolecules.	Properties and uses and reactions of organic compounds, organic macromolecules and biological macromolecules.
4 Difficulties/limitations connected with teaching this idea?	Make sure that learners understand that compounds with the same functional group will be named in the same way and will undergo the same type of reaction.	Learners need step by step examples to follow the rules of naming and drawing Isomers can look different but can be the same; isomers have different structural arrangements and therefore different names.
5 Knowledge about the learners thinking which might influence your teaching of this idea?	Give learners examples of classification to practise. Test for un-saturation is recommended for formal assessment to evaluate the design, experiment and findings of learners.	Allowing learners to work as individuals, in pairs and in groups- stronger learners will tutor weaker peers. Need to emphasize the location of -OH group Need for learners to understand hydrogen bonding- in carboxylic acids and alcohols
6 Teaching procedures and reasons for using these to engage the idea?	Content on classification Use of tables to show functional groups in main classes of organic molecules-arrangement of atoms. How about this? - setting for the idea of organic chemistry historically. Use of a concept map to show the major and sub-classes of hydrocarbons? Use of a practical to show how to classify as saturated and unsaturated. Use of signposts in chapter to show learners how to access material in other chapters. In chapter exercise on classifying organic compounds.	Content on naming alkanes, alkenes and alkynes; alcohols; aldehydes and ketones; carboxylic acids; esters; amines and amides Table to name first 10 alkanes with number of carbon atoms, prefix and condensed formula. Worked example for identifying isomers, naming and drawing alkyl groups, structural formula alkenes; alcohols; carboxylic acids; In chapter exercise on writing structural isomers. Information/rules to draw the structural formula of a known compound. Activity to name and draw alkanes; naming and drawing alkenes and alkynes; Use of textboxes to draw learner's attention to important details e.g. R represents an alkyl group, numbers in names need to be separated by a hyphen.;Exercise on writing structural formulae for alkenes and alkynes In chapter activity on naming and drawing carboxylic acids; Activity on understanding esters:- involves naming esters Figure on structure of benzene

Table 5.3 CoRe Big Ideas 3&4

BIG IDEA/ PROMPTS	ORGANIC COMPOUNDS SHOW PHYSICAL PROPERTIES	ORGANIC REACTIONS DEPEND ON THE DISTINCTIVE CHEMICAL PROPERTIES OF ORGANIC MOLECULES.
1 What do you intend your learners to learn about this idea?	General formulas; homologous series; isomers; crude oil- heterogeneous mixtures; phases; densities; solubility (organic compounds are non-polar, do not dissolve in water); have weak van der Waals forces, boiling and melting points; effects of branching; vapour pressure, reactivity; alkenes as monomers. Uses of organic compounds	Reactive sites in the molecule (functional groups) cause groups of compounds to undergo predictable reactions. Organic compounds typically undergo addition, substitution and elimination reactions; can act as acids and bases. Test for saturation is addition; Alkanes generally undergo Combustion reactions, halogenation reactions (substitution); cracking(elimination reactions; reactions of alkenes and alkynes- halogenations; hydrogenation and polymerization reactions; reactions with ketones and aldehydes, reactions to form esters(alcohols and carboxylic acids); reactions with benzene
2 Why is it important for the learners to know this?	To understand importance of organic chemistry in the real world.	To understand importance of organic chemistry in the real world.
3 What else do you know that the learners do not need to know yet?	Reactions of different organic compounds; Properties and uses and reactions of organic compounds, organic macromolecules and biological macromolecules.	Properties and uses and reactions of organic compounds, organic macromolecules and biological macromolecules.
4 Difficulties/limitations connected with teaching this idea?	Although it can be interesting this big idea can involve a lot of time-discussions, debates etc.	Reactions take place at a functional group (e.g. Multiple bond) Esters can be made from a carboxylic acid and an alcohol and can be split back into the starting materials
5 Knowledge about the learners thinking which might influence your teaching of this idea?	Opportunity for learners to understand the damaging effects of alcohol e.g. Response time, vision and hearing, unborn babies as well as health risks associated with smoking etc. in an environment apart from usual parental controls- science associated with information they may already know something about.	Learners need to develop research skills research Practical activity on esters provides support for the theory Practical activity on test for un-saturation provides support for the theory.
6 Teaching procedures and reasons for using these to engage the idea?	Content on uses of alkanes; alkenes and alkynes; alcohols, ketones and aldehydes, carboxylic acids, esters, uses and properties of amines and amides. Activity on examining the relationship between size of an alkane and its boiling point. Use of signposts to show learners where more information on properties of alkanes may be found. Picture showing oxyacetylene torch. Case study on effects of alcohol on unborn children. Researching the effects of alcohol. How about this? –legalities around drinking alcohol-breathalyser kits-chemistry (redox) Picture to show in which products aldehydes and ketones may be found. Activity on Investigating some aromatic compounds (structure and uses) – research assignment. Case study- Health risks of benzene in coal and tobacco smoke. Activity on summarizing information- important properties and uses.	Balanced chemical reactions given as examples for alkanes, alkenes, alkynes; benzene reactions esters, Signposts given to information in other chapter- cracking; polymerization, production of soap Activity for completing addition reactions Practical on making esters Activity to summarise knowledge on hydrocarbons into a table

5.2.1: BIG IDEA 1 CARBON IS UNIQUE CARBON IS UNIQUE IN ITS ABILITY TO FORM CHAINS AND RINGS.

In this first Big Idea the authors show that carbon has a central role in the chemistry of living organisms and has a unique capacity to bond in long, durable chains that have branches or rings. Carbon can also bond with other atoms such as hydrogen, oxygen and nitrogen.

The characteristics of organic molecules, the differences between aliphatic and aromatic hydrocarbons, functional groups as an arrangement of atoms, differences between saturated and unsaturated hydrocarbons depend on this unique characteristic.

The authors expected that the learners would already know the work covered in grade 11 chemical change and chemical systems; types of reactions i.e. redox; acid/base as well as substitution, addition and elimination.

The authors used structures to review the unique properties of carbon that was covered in grade 11 and to show various models for representing organic molecules. The teaching ideas used by the authors include:

- The content on classification in which they used tables to show the functional groups of the main classes of molecules to emphasise the arrangement of atoms (Figure 5.14).
- A text box labelled “How about this?” to reinforce the historical importance of organic chemistry (pg152)
- A mind map to show the major classes and subclasses of hydrocarbons.(pg 154)
- A practical investigation to demonstrate the difference in chemical properties between saturated and unsaturated compounds (pg 154 & 155)
- Use of signposts within the chapter to show the learners how to access information in other chapters of the book (pg 158)
- Use of notes to draw the learners attention to important facts (pg 153)
- An in-chapter exercise on classifying organic compounds (Figure 5.15)

Functional group	Class of compound	Example
–C=C–	alkene	$CH_2=CH_2$
–C≡C–	alkyne	$HC\equiv CH$
–C–OH	alcohols	CH_3CH_2OH
–C–O–C–	ether	$CH_3–O–CH_3$
O || –C–H	aldehyde	O || CH_3CH
O || –C–C–C–	ketone	O || CH_3CCH_3
O || –C–OH	carboxylic acid	O || $CH_3–C–OH$
O || –C–O–C–	ester	O || $CH_3C–O–CH_3$
$–C–NH_2$	amine	$CH_3–NH_2$
O || $–C–NH_2$	amide	O || $CH_3C\ NH_2$

Figure 5.14: Table on functional groups

Activity 5.1 Classifying organic compounds (individual)

LO2 AS1

Study the table of functional groups on the previous page.

1. Classify the following compounds on the basis of their functional groups:

(a) $CH_2=CHCH_3$ (b) $CH_3–O–CH_2CH_3$ (c) $CH_3CH_2NH_2$

(d) $CH_3CH_2CH_2OH$ (e) $CH_3CH_2C(=O)CH_3$ (f) $CH_3CH_2CH_3$

(g) $CH_3CH_2C(=O)OH$ (h) $CH_3CH_2C(=O)–O–CH_3$ (i) $CH_3CH_2C(=O)H$

2. Which of the compounds above is an example of a saturated hydrocarbon?
3. Which of the compounds above is an example of an unsaturated hydrocarbon?

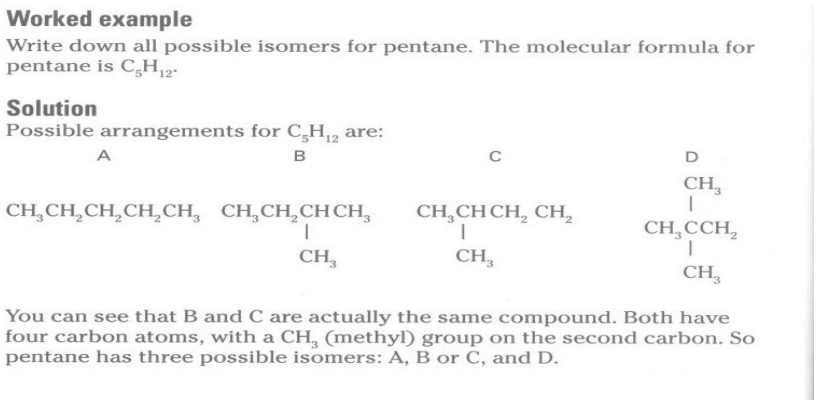
Figure 5.15: In chapter activity

5.2.2: BIG IDEA 2 THERE ARE MULTIPLE WAYS OF REPRESENTING ORGANIC SUBSTANCES WHICH ARE NAMED USING A STANDARD SYSTEM (IUPAC) OF NAMING.

The authors intended the learners to understand Lewis and Couper notation, the differences between structural formulae and molecular formulae, full structural formulae and condensed structural formulae, the concept of isomers and the IUPAC rules for naming and drawing.

The teaching procedures used for teaching this idea are:

- Content on naming alkanes, alkenes and alkynes; alcohols, aldehydes and ketones, carboxylic acids, esters, amines and amides.
- Table to name the first 10 alkanes with number of carbons, prefix and condensed formulae. (pg 156)
- Worked example for identifying isomers (Figure 5.16), naming and drawing alkyl group, structural formulae of alkenes, alcohols and carboxylic acids. (pg 156, 157,160)
- An in-chapter exercise on writing structural isomers (pg 157)
- Text box with information on how to draw structural formulae. (pg 158)
- Activity on naming and drawing alkanes, alkenes and alkynes. (pg 158 & 160)
- Use of textboxes to draw learners' attention to important information (pg 157)
- In chapter exercise on writing structural formulae for alkenes and alkynes (pg 161) and naming drawing carboxylic acids (pg165) and understanding and naming esters (pg 166)
- Figure on structure of benzene (pg168) showing Kekulé ring as well as a full structural formula. (pg 168)



Worked example

Write down all possible isomers for pentane. The molecular formula for pentane is C_5H_{12}.

Solution

Possible arrangements for C_5H_{12} are:

A: $CH_3CH_2CH_2CH_2CH_3$

B: $CH_3CH_2CH(CH_3)$

C: $CH_3CH(CH_3)CH_2CH_2$

D: $CH_3C(CH_3)_2CH_2$

You can see that B and C are actually the same compound. Both have four carbon atoms, with a CH_3 (methyl) group on the second carbon. So pentane has three possible isomers: A, B or C, and D.

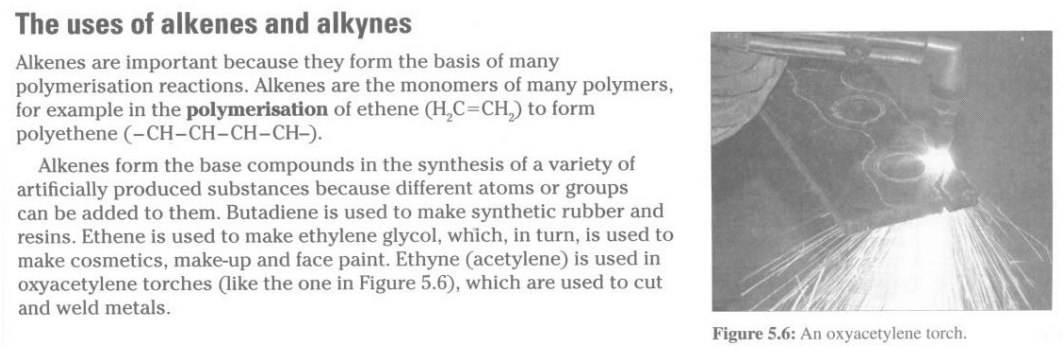
Figure 5.16: Worked example on isomers

5.2.3 BIG IDEA 3: ORGANIC COMPOUNDS SHOW DISTINCTIVE PHYSICAL PROPERTIES.

The third Big Idea involves the distinctive physical and chemical properties of organic compounds. The authors intend the learners to understand general formulae with regard to alkenes, alkanes and alkynes; the concept of a homologous series,

isomers, heterogeneous mixtures, different phases, densities, solubility, effects of branching, vapour pressures, reactivity and alkenes as monomers. They used the following ways to engage the learners with the content:

- Content on uses and properties of alkanes, alkenes and alkynes, alcohols, ketones, aldehydes, carboxylic acids, amines and amides.
- Activity on examining the relationship between size of an alkane and boiling point (pg 158)
- Use of signposts to show learners where more information on properties of alkanes can be found (pg 158)
- Picture showing an oxyacetylene torch (Figure 5.17)
- Case study on the effects of alcohol on unborn children and activity on researching the effects of alcohol. (pg 163)
- Text box “How about this?” on the use of redox reactions in breathalyser kits. (pg 163)
- Pictures showing in which commercial products aldehydes, ketones and alcohols may be found. (pg 163 and 164)
- Activity on investigating aromatic compounds- a research assignment.(pg 168)
- Case study on the health risks of benzene and tobacco smoke (Figure 5.18)



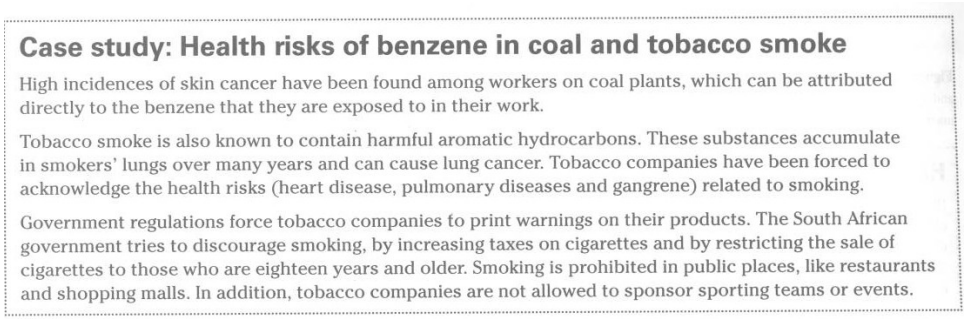
The uses of alkenes and alkynes

Alkenes are important because they form the basis of many polymerisation reactions. Alkenes are the monomers of many polymers, for example in the **polymerisation** of ethene ($H_2C=CH_2$) to form polyethene (–CH–CH–CH–CH–).

Alkenes form the base compounds in the synthesis of a variety of artificially produced substances because different atoms or groups can be added to them. Butadiene is used to make synthetic rubber and resins. Ethene is used to make ethylene glycol, which, in turn, is used to make cosmetics, make-up and face paint. Ethyne (acetylene) is used in oxyacetylene torches (like the one in Figure 5.6), which are used to cut and weld metals.

Figure 5.6: An oxyacetylene torch.

Figure 5.17: Picture showing an oxyacetylene torch



Case study: Health risks of benzene in coal and tobacco smoke

High incidences of skin cancer have been found among workers on coal plants, which can be attributed directly to the benzene that they are exposed to in their work.

Tobacco smoke is also known to contain harmful aromatic hydrocarbons. These substances accumulate in smokers' lungs over many years and can cause lung cancer. Tobacco companies have been forced to acknowledge the health risks (heart disease, pulmonary diseases and gangrene) related to smoking.

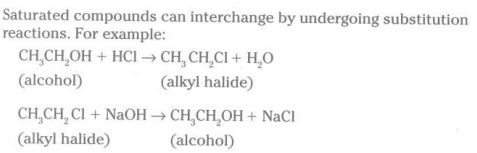
Government regulations force tobacco companies to print warnings on their products. The South African government tries to discourage smoking, by increasing taxes on cigarettes and by restricting the sale of cigarettes to those who are eighteen years and older. Smoking is prohibited in public places, like restaurants and shopping malls. In addition, tobacco companies are not allowed to sponsor sporting teams or events.

Figure 5.18: Case study: Health risks of benzene in coal and tobacco smoke

5.2.4 BIG IDEA 4: ORGANIC REACTIONS DEPEND ON THE DISTINCTIVE CHEMICAL PROPERTIES OF ORGANIC MOLECULES.

In this Big Idea the authors focus on organic reactions in which reactive sites in molecules or functional groups can cause groups of compounds to undergo predictable reactions such as combustion, addition, substitution and elimination reaction and can also act as acids and bases. They used the following ways to engage the learners with the content:

- Balanced chemical equations given as examples for alkanes (Figure 5.19) alkenes, alkynes; benzene reactions and reactions to make esters (pg 153,155,159)
- Signposts given to information in other chapter- cracking; polymerization, production of soap (pg159, 161,166)
- Activity for completing addition reactions (pg 161)
- Practical on making esters (Activity and practical activity pg 166)
- Activity to summarise knowledge on hydrocarbons into a table (Activity 16 pg 169)



Saturated compounds can interchange by undergoing substitution reactions. For example:

$CH_3CH_2OH + HCl \rightarrow CH_3CH_2Cl + H_2O$

(alcohol) (alkyl halide)

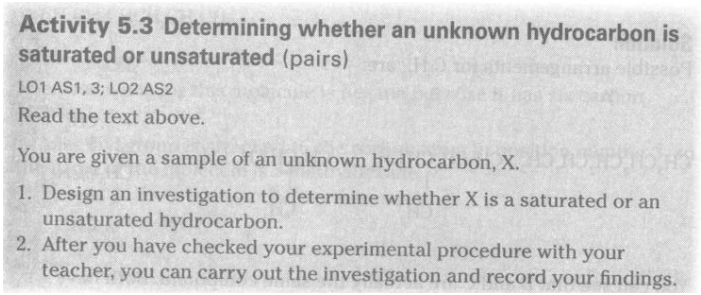
$CH_3CH_2Cl + NaOH \rightarrow CH_3CH_2OH + NaCl$

(alkyl halide) (alcohol)

Figure 5.19: Examples of substitution reactions[1]

[1] The authors are trying unsuccessfully to describe the reversibility of the reactions in which alcohols react to form alkyl halides and alkyl halides react to become alcohols. "Can interchange" is not clearly expressed.

It is important for the learners to understand that alkanes undergo substitution reactions while alkenes and alkynes undergo addition reactions.



Activity 5.3 Determining whether an unknown hydrocarbon is saturated or unsaturated (pairs)

LO1 AS1, 3; LO2 AS2

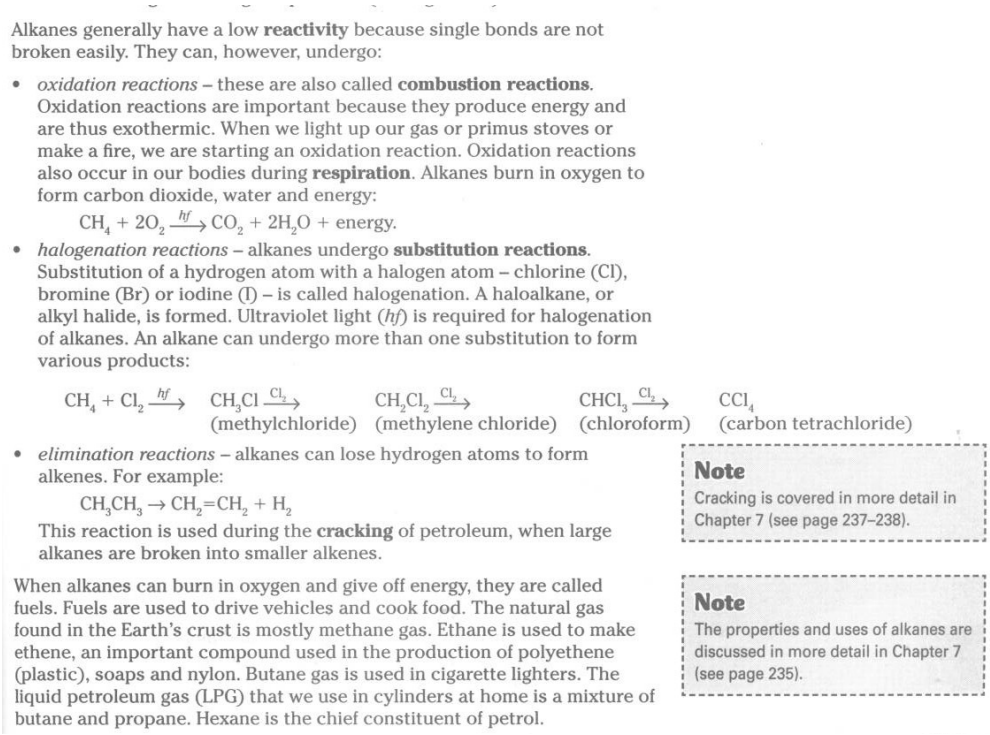
Read the text above.

You are given a sample of an unknown hydrocarbon, X.

1. Design an investigation to determine whether X is a saturated or an unsaturated hydrocarbon.
2. After you have checked your experimental procedure with your teacher, you can carry out the investigation and record your findings.

Figure 5.20: determining whether hydrocarbons are saturated or unsaturated- substitution and addition reactions

The above example (Figure 5.20) shows the learners how to differentiate between alkanes and alkenes/alkynes.



Alkanes generally have a low **reactivity** because single bonds are not broken easily. They can, however, undergo:

- *oxidation reactions* – these are also called **combustion reactions**. Oxidation reactions are important because they produce energy and are thus exothermic. When we light up our gas or primus stoves or make a fire, we are starting an oxidation reaction. Oxidation reactions also occur in our bodies during **respiration**. Alkanes burn in oxygen to form carbon dioxide, water and energy:

  $CH_4 + 2O_2 \xrightarrow{hf} CO_2 + 2H_2O$ + energy.

- *halogenation reactions* – alkanes undergo **substitution reactions**. Substitution of a hydrogen atom with a halogen atom – chlorine (Cl), bromine (Br) or iodine (I) – is called halogenation. A haloalkane, or alkyl halide, is formed. Ultraviolet light (*hf*) is required for halogenation of alkanes. An alkane can undergo more than one substitution to form various products:

  $CH_4 + Cl_2 \xrightarrow{hf}$ CH_3Cl (methylchloride) $\xrightarrow{Cl_2}$ CH_2Cl_2 (methylene chloride) $\xrightarrow{Cl_2}$ $CHCl_3$ (chloroform) $\xrightarrow{Cl_2}$ CCl_4 (carbon tetrachloride)

- *elimination reactions* – alkanes can lose hydrogen atoms to form alkenes. For example:

  $CH_3CH_3 \rightarrow CH_2{=}CH_2 + H_2$

  This reaction is used during the **cracking** of petroleum, when large alkanes are broken into smaller alkenes.

Note
Cracking is covered in more detail in Chapter 7 (see page 237–238).

When alkanes can burn in oxygen and give off energy, they are called fuels. Fuels are used to drive vehicles and cook food. The natural gas found in the Earth's crust is mostly methane gas. Ethane is used to make ethene, an important compound used in the production of polyethene (plastic), soaps and nylon. Butane gas is used in cigarette lighters. The liquid petroleum gas (LPG) that we use in cylinders at home is a mixture of butane and propane. Hexane is the chief constituent of petrol.

Note
The properties and uses of alkanes are discussed in more detail in Chapter 7 (see page 235).

Figure 5.21: Oxidation reactions, halogenations reactions and elimination reactions as well as signposts to other chapters.[234]

[2] Single bonds referred to in the figure are presumably carbon to carbon single bonds but this is not clear.
[3] Energy cannot be formed in a combustion reaction.
[4] Hexane is not the chief constituent of petrol.

The above example (Figure 5.21) shows the learners three of the most important reactions of the alkanes i.e. combustion, substitution (halogenation) and elimination with examples of each. The authors make use of signposts to the properties and uses of the alkanes as well as cracking (elimination) which is discussed in more detail in chapter 7. They do not discuss the details of the mechanisms of the reactions or major and minor products.

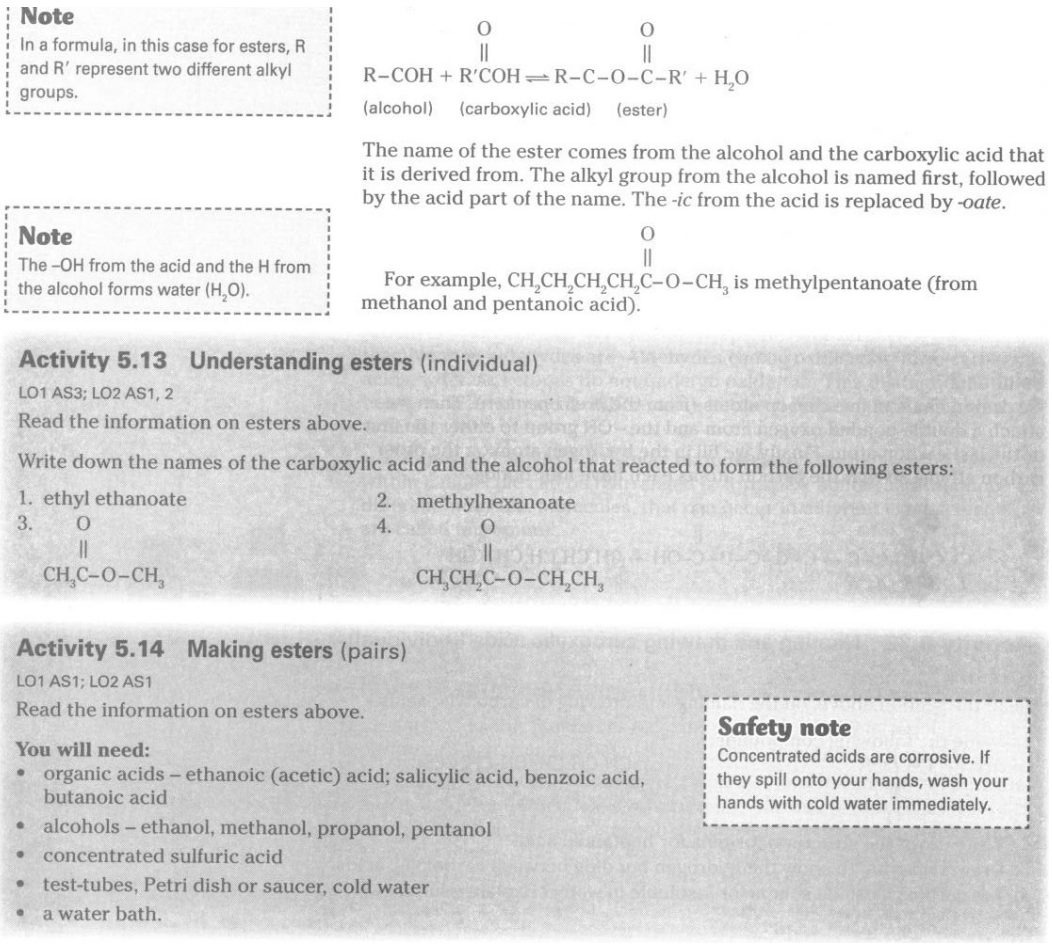


Figure 5.22: Activities on understanding and making esters and esters as functional groups

5.2.5 KNOWLEDGE OF THE CURRICULUM

The authors demonstrated knowledge of the curriculum throughout the chapter. This was evident on the title page to the chapter with a mind map of what the chapter contained, although these just appeared to be topic headings, as well as the learning outcomes (Figure 5.5) and assessment standards used in the chapter. In every

activity throughout the chapter the learning outcomes and assessment standards are clearly shown.

Activity 5.16 Summarising hydrocarbons (individual)

LO2 AS1, 2

Review the material in this unit. Then copy and complete this table to summarise what you have learnt about organic molecules.

Subclass	Examples	Important properties	Uses
alkanes			
alkenes and alkynes			
alcohols			
aldehydes and ketones			
carboxylic acids			
esters			
amines and amides			

Figure 5.23: Learning Outcomes and Assessment standards for Activity 5.16

The curriculum is the body of knowledge that the authors want to share with the learners and it also attempts to achieve certain ends in the learners. It is also the process that both authors and learners have to go through to achieve these ends. It is not the syllabus as this would only refer to the body of knowledge and not the way in which it is transformed. However, as was mentioned in the previous chapter the examination guidelines were used as the curriculum document as this was the actual material that the grade 12 learners are examined on and it has to be pointed out that it does not coincide with what was originally planned and the authors had no knowledge of what changes would be made subsequent to the original implementation of the curriculum.

However the authors gave their take on what was to be taught and learned and how this was to happen by selecting the various tasks and activities throughout the chapter. They also decided on the sequencing of the teaching and learning. The exercises and summative assessment are ways of the learners evaluating their progress. Another way of understanding the idea of the textbook as the curriculum document is the learners rely on it while preparing for their examinations.

However this knowledge did not always coincide with the examination guidelines. As previously stated the examination guidelines were used as the 'curriculum document' as this is the actual material that the grade 12 learners are examined on. The authors did not have prior knowledge of what the examiners would put into the

examination guidelines while writing the textbook. The information that is missing is shown in table 5.4 below.

Table 5.4 Missing Information from Physical Sciences Explained.

MAIN TOPICS OF DOE EXAMINATION GUIDELINES 2009	FOCUS ON PHYSICAL SCIENCES INFORMATION MISSING FROM CONTENT
Organic molecular structures-functional groups, saturated and unsaturated structures, isomers, systematic naming and formulae	The term substituent group not used. Examples of alkanes only include 1 branch. Naming of cyclo-alkanes with or without alkyl substituent groups. Naming of alkenes with alkyl substituent groups. Isolated and cumulated dienes Naming of alkynes with alkyl substituent groups. Naming of halo-alkanes, cyclo haloalkanes Primary, secondary and tertiary alcohols, alkyl substituents Branched carboxylic acids. N and N,N in naming of amines. Acyl group Naming of aldehydes Naming of ketones
Structure and physical property relationships	Viscosity [reference oily liquids]
Substitution, addition and elimination reactions	Addition reactions of alkynes &reaction conditions; H atom attaches to carbon atom with the greater number of H atoms; X atom attaches to the more substituted C atom. Hydration-reaction conditions, position of attachment of OH group. Hydrogenation-reaction conditions i.e. non polar solvent. Elimination-Dehydro-halogenation; reaction condition, major and minor products. Dehydration reactions-reaction conditions, minor and major products. Substitution reactions-inter-conversion between alcohols and haloalkanes, primary and secondary bromoalkanes, reaction conditions. Reactions of bases with haloalkanes to produce alcohols, reaction conditions

5.2.6 KNOWLEDGE OF THE CONTENT

The authors showed a flexible and comprehensive understanding of the subject matter that they were presenting. There are numerous examples throughout the chapter. Some examples showing the authors' knowledge of the content are:

- Table on naming alkanes (pg 156)
- Worked example on naming of a branched alkane (pg 157)

1.3 Alkanes and their properties

Naming alkanes

Note
It is very important that you learn to name these basic compounds because we use this as a basis for naming other organic molecules.

Alkanes have a general formula of C_nH_{2n+2}, where *n* indicates the number of carbon atoms. The names of alkanes end in the suffix *-ane*. The prefix tells us how many carbon atoms are in the molecule. The table below shows the name, number of carbon atoms, parent name and formula of the first ten straight-chained (normal) alkanes:

Name	Number of carbon atoms	Prefix	Condensed formula
methane	1	meth-	CH_4
ethane	2	eth-	CH_3CH_3
propane	3	prop-	$CH_3CH_2CH_3$
butane	4	but-	$CH_3CH_2CH_2CH_3$
pentane	5	pent-	$CH_3CH_2CH_2CH_2CH_3$
hexane	6	hex-	$CH_3CH_2CH_2CH_2CH_2CH_3$
heptane	7	hept-	$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$
octane	8	oct-	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$
nonane	9	non-	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$
decane	10	dec-	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

Figure 5.24: Naming Alkanes

Worked example
Name the following compound:

$CH_3CH_2CHCH_2CH_3CH_3$
with CH_3 attached to the third carbon atom

Solution
Number the longest chain of carbon atoms. If we number from left to right, the methyl group is attached to the carbon atom in position number 3. (If we had numbered it from right to left, it would have been on the carbon atom in position number 4.)

1 2 3 4 5 6
$CH_3CH_2CHCH_2CH_2CH_3$
with CH_3 attached to carbon atom 3

The base name for this molecule is hexane because it has six carbon atoms.

A methyl group is attached to the carbon atom in position number 3, so the name of the molecule is 3-methylhexane.

Note
When you name organic compounds, you always need to separate numbers from letters with a hyphen.

Figure 5.25: Worked example and solution to naming a branched alkane[5]

The authors also used notes like the one in the example above to draw the learners' attention to specific details in the content.

In the example in Figure 5.22 the authors show the learners how esters are derived from carboxylic acids and alcohols. The notes are meant to help the learners understand where the removed water comes from.

5 Error in the formula given in the worked example in Figure 5.25.

5.2.7 KNOWLEDGE OF THE CONTEXT

There is also evidence in this chapter of knowledge of the context from which the content is taken. In the example below (Figure 5.26) in the fairly simplistic drawing the learners can see in which everyday products alcohols are used. The learners are also alerted to some of the dangers of alcohol consumption.

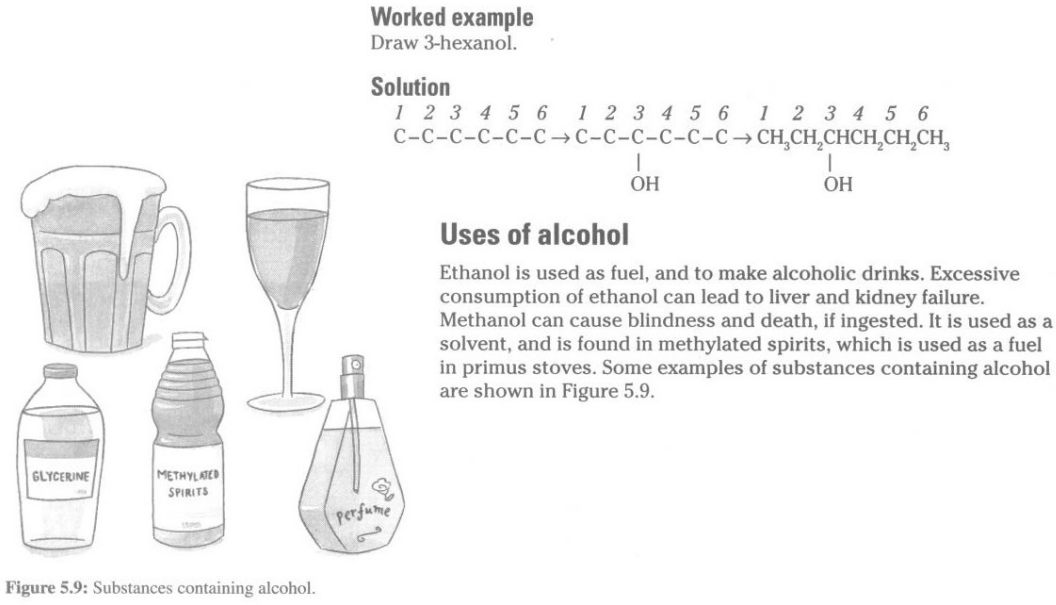


Figure 5.26: Uses of Alcohol[6]

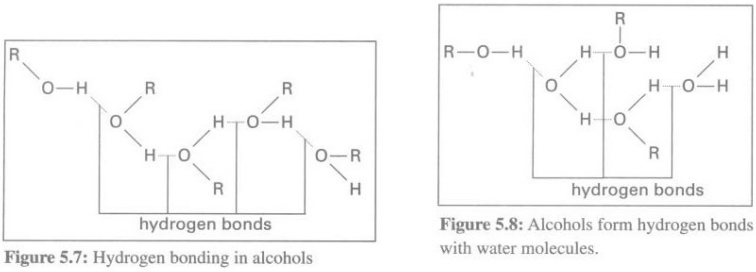


Figure 5.27: Hydrogen bonding in alcohols

Figure 5.27 shows knowledge of the learners' context as well as knowledge of the curriculum. The section on intermolecular forces is taught in grade 11 but is extremely important for the learners to understand when hydrogen bonding will occur

[6] The authors use the term alcohol as only one can exist. The term refers to a homologous series of compounds.

and how it will affect boiling and melting points. Knowledge of the context links the learners understanding of the topic to work that has been previously taught as well as to the real world which is what LO3 encompasses.

7.3.1 Explain the increase in boiling points and melting points of alkanes with increasing size, by referring to intermolecular forces. (3)

7.3.2 Draw a graph of the number of carbon atoms (horizontal axis) versus boiling point (vertical axis) for the alkanes in the table. (3)

7.3.3 Use your graph to estimate the boiling point of heptane (C_7H_{16}). (2)

7.3.4 Name the alkanes that exist as liquids below 120 K. (1)

7.3.5 Which alkanes are solids at 92 K? (1)

[26]

How to approach Question 7

- 7.1: You will need to recall that an ester is formed by the reaction between an alcohol and a carboxylic acid.
- 7.3.1: You will need to recall how intermolecular forces are related to the size of a molecule. Recognise that the stronger the intermolecular forces are, the more difficult it is to separate the molecules.
- 7.3.3: You will need to interpolate to find the boiling point.
- 7.3.4: Recognise that 120 K (or higher) is a boiling point for the substances that are to be identified.
- 7.3.5: Recognise that 92 K (or higher) is the melting point for the substances that are to be identified.

47

Figure 5.28: How to approach an examination question in a practice exam as well as part of the question.

In the example in Figure 5.28 the authors are helping the learners put the exam question into context (intermolecular forces) and stimulate the learner's thinking about important issues in this section by asking the learner to recall information on the different types of intermolecular forces that could be present in between the molecules and that the strength of intermolecular forces relates to the size of the molecule and how this in turn relates to the boiling and melting points.

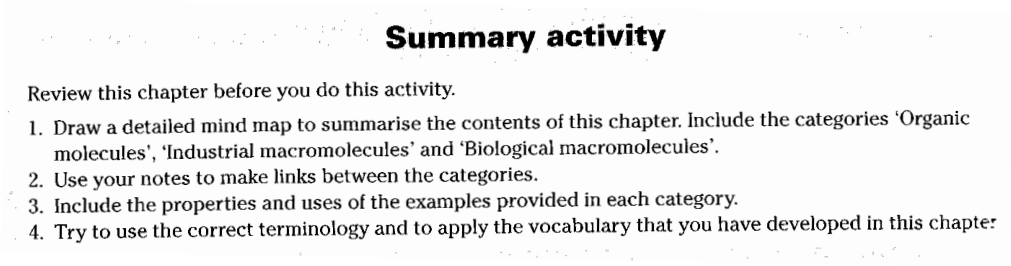
Once the learners have drawn the graph from the table they are reminded to interpolate[7] from the graph to estimate the boiling point of heptane. To identify which are liquids and which are solids the learners need to understand that temperatures of 120K or higher is the boiling point of the substances to be identified and that temperatures of 92K or higher is the melting point of the substances to be identified.

[7] Estimate value of a mathematical function that lies between known values often by means of a graph

This shows the authors' PCK relating to learners' ability to recognise and understand questions they may be unfamiliar with as well as giving the learners a sense of direction on how to answer the question. Learners are often not able to make the necessary connections when answering examination questions. Comprehension also depends on the learners recalling prior knowledge which in this case is the knowledge about intermolecular forces which is taught in grade 11. This kind of help allows the learner make sense of the text and to put it into the correct context.

5.2.8 KNOWLEDGE OF VALUES ENDS AND PURPOSES

The authors have shown knowledge of values, ends and purposes which cannot be separated from evaluation and assessment procedures. An example (Figure 5.29) of this is shown in the summary activity.



Summary activity

Review this chapter before you do this activity.

1. Draw a detailed mind map to summarise the contents of this chapter. Include the categories 'Organic molecules', 'Industrial macromolecules' and 'Biological macromolecules'.
2. Use your notes to make links between the categories.
3. Include the properties and uses of the examples provided in each category.
4. Try to use the correct terminology and to apply the vocabulary that you have developed in this chapter

Figure 5.29: Summary Activity

In this activity the authors encourage the learners to make a mind map to summarise the contents of the chapter by including categories, notes, properties, examples and the correct terminology. Subject matter knowledge has to include opportunities for the learners to re-examine the content for themselves. The book also includes a glossary of terms used in the book as well as an index which makes for easy reference.

Science is however more than just a body of knowledge to be learned as it encompasses certain human values such as curiosity, creativity and questioning. It also should support the role of women and minorities. Although, apart from an activity about the effects of alcohol on unborn children, there is no evidence in the chapter supporting women or minorities and there is also no evidence that men are supported. A picture of an oxyacetylene torch shows only the flame and not the person holding the torch.

5.2.9 KNOWLEDGE OF LEARNERS AND LEARNING

The above example (Figure 5.29) also shows knowledge of learners and learning. The mind map is meant to help the learners to prepare and study for end of chapter summative assessment. The authors have also provided the learners with an examination practice book. The first section of the booklet provides the learners with:

- Useful information relating to the subject and requirements for successful completion of the course.
- Hints and tips for examination preparation and writing of examinations.
- A glossary section that explains the words used in examinations such as explain, evaluate, determine, outline etc.

Sections 2 and 3 provide the main focus of the booklet which includes both a physics and a chemistry paper. There are notes on how to approach the questions as well as model answers to the question papers.

Sections 5 and 6 contain complete examination papers that were modelled on what the learners should expect in the final examination. A complete memorandum is also included. The authors suggest that the learners try to complete the examination papers within the correct time frame before being marked. The authors suggest that it is an ideal resource as a complete examination revision. It is the only textbook of those analysed that provides a tool such as this.

Knowledge of the learners and learning needs to incorporate an understanding of misconceptions, how they have come about as well as teaching strategies to address them. The textbook does give learners signposts to other information in the text as well as to grades 10 and 11 and therefore the authors are aware of the learners misconceptions and the need to address them.

An example of this is the Activity 6 which examines the relationship between the molecular size of an alkane and its boiling point. The teaching guidelines for the activity acknowledge that the activity involves interpretation skills (drawing conclusions from data) and reading information from a graph. They advise the teacher to revise graphs while reminding the learners about dependent and

independent variables as well as direct[8] and indirect relationships. It is not clear from the Teacher's Guide whether the authors know that this should be inverse[9] proportion. They also indicate that the learners should refer to their knowledge of intermolecular forces from grade 10.

The authors also give suggestions in the Teachers' Guide for both remedial and enrichment strategies. They encourage the teachers to show the learners the patterns in the chemistry e.g. in a homologous series, and suggest that the learners will learn through practice and repetition. The enrichment strategy suggests that learners can be provided with additional activities which may involve more complex organic compounds.

5.2.10 GENERAL PEDAGOGICAL KNOWLEDGE

The authors have also demonstrated general pedagogical knowledge in the general layout of the chapter and the book. This refers to the manner and the order in which information, activities and notes have been included in the chapter. An example of this is found in a summary of key concepts which includes a summary of the principal functional groups in Figure 5.30.

[8] The relation between quantities whose ratio remains constant, when A changes then B changes by the same factor; also called direct ratio

[9] Two quantities, A and B, are in inverse proportion if by whatever factor A changes, B changes by the reciprocal of that factor.

Summary of principle functional groups in organic compounds

Type of compound	General formula	Structural formula	Common examples
alkanes	C_nH_{2n+2}	CH_3CH_3 (ethane)	methane, butane
alkenes	C_nH_{2n}	$CH_2=CH_2$ (ethene)	propene, butene
alkynes	C_nH_{2n-2}	$CH{\equiv}CH$ (ethyne)	acetylene (ethyne)
alcohols	$C_nH_{2n+1}OH$ (R–OH)	CH_3CH_2OH (ethanol)	methanol, ethanol
aldehydes	$C_nH_{2n}O$ (R–CHO)	CH_3CHO (ethanal)	ethanal (formaldehyde)
ketones	$C_nH_{2n}O$ (R–CO–R′)	CH_3COCH_3 (propanone)	acetone, testosterone
carboxylic acids	$C_nH_{2n}O_2$ (RCOH or RCOOH)	CH_3–CO–OH (ethanoic acid)	benzoic acid, lactic acid
esters	$C_nH_{2n}O_2$ (RC–O–R′)	CH_3CO–O–CH_3 (methyl ethanoate)	methyl salicylate (Deep Heat)
amines	$C_nH_{2n-1}NH_2$ (R–NH_2)	CH_3CH_2–NH_2 (ethylamine)	methylamine
amides	$C_nH_{2n-1}ONH_2$ (R–$CONH_2$)	CH_3CONH_2 (ethanamide)	nylon

Figure 5.30: Summary of principal functional groups.[10]

The Exam Bank questions which allows teachers to find questions and put them together in worksheets, tests and exams. Suggested memoranda are also provided.

5.3 OVERVIEW OF THE CHAPTER

A general description of the book and the mediation of the chemistry content are described in this chapter of Focus on Physical Sciences, which was published by Maskew, Miller and Longman for the new curriculum. The section on organic chemistry is found in chapter 5 and is consistent with the other chapters in the book which all contain clear, comprehensive instructions and signposts. An index and a glossary have been included in the book and the glossary terms appear in bold in the text. The reading level is age appropriate, the print size common to most printed media and the format is appealing and interesting. The selection of 16 activities, which include practical activities, and pictures etc. are correctly referenced in the text and come with some teaching guidelines for each activity.

The Teacher's Guide includes useful information on the curriculum, learning outcomes, assessment guidelines, assessment checklists and rubrics as well as limited teaching guidelines.

[10] The spelling of principal is incorrect in the heading of the table.

The Exam Bank CD ROM provides the teacher with a tool for setting activities, tests and examinations from a large database which can be edited and suggested solutions can be compiled. Unfortunately this resource is not compatible with Windows 7 and some of the questions and types of questions are no longer compatible with the current examinations.

The FET Practical Book is design to cover practical work for grades 10, 11 and 12 and includes planning, designing, setting up and conducting practical investigations.

The Exam Practice Book includes some useful information for the learners on how to prepare for examinations as well as containing worked examination papers showing the learners how each question should be approached as well as practice examination papers for the learners to complete.

The mediation of the chemistry content begins with the big ideas extracted from the text in the form of a CoRe (content representation). Examples from the text have been selected to illustrate these big ideas. the big ideas are: 1.Carbon is unique in its ability to form chains and rings ; 2.There are multiple ways of representing organic substances which are named using a standard system (IUPAC) of naming; 3.Organic compounds show distinctive physical and chemical properties; and 4.Organic reactions depend on the distinctive physical and chemical properties of organic molecules to determine the types of reactions they undergo.

Each of the knowledge bases from Bishop and Denley's model have been described together with relevant examples from the text in an attempt to identify the PCK of the authors. The authors have demonstrated a comprehensive amount of PCK in the various ways they have addressed teaching and learning through the way the textbook is organised.

In chapter 6 the textbook Physical Sciences Explained is described.

CHAPTER 6 PHYSICAL SCIENCES EXPLAINED

6.1 INTRODUCTION

In this chapter the textbook 'Physical Sciences Explained' and how the authors have mediated the organic chemistry content, is described.

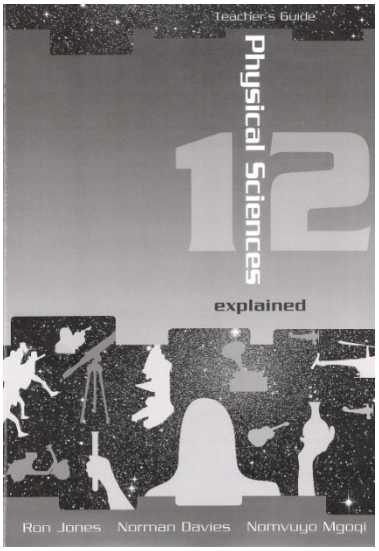


Figure 6.1 Teacher's Guide

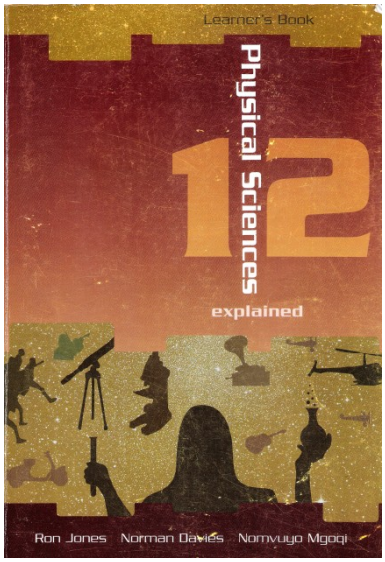


Figure 6.2 Learner's Book

Authors):	Ron Jones; Norman Davies & Nomvuyo Mgoqi
ISBN:	978-0-7021-7361-5
Publisher:	Juta Gariep
Series:	Physical Sciences Explained Grades 10 to 12
Grade	12

Table 6.1 Details of Physical Sciences Explained.

The book (Table 6.1) was first published by Juta Gariep in 2007 in Cape Town, South Africa. The book is 20.8 cm by 29.2cm and is larger in size than the other two textbooks reviewed. There is a Learner's Textbook (Figure 6.2) and a Teacher's Guide (Figure 6.1) unlike the book described in chapter 5.

6.1.1 THE LEARNER'S BOOK

The section on organic chemistry is found in Module 4, Section B and consists of 31 pages covering 5 units, which include content, diagrams, tables and 'in chapter' questions etc. Including the glossary the book consists of 324 pages and therefore the organic chemistry content accounts for about 9.6% of the book.

According to the publishers this book "has been carefully designed to help learners develop an understanding of challenging physics and chemistry concepts. Content is presented simply, and is well illustrated and explained. Questions and activities encourage learners to engage with the information. Issues of "science and society" which are new to the curriculum are given particular emphasis.

The layout of these chapters is consistent with other chapters within the book. The sequence of the chapters is logical and the chapter contains clear and comprehensive instructions or signposts. The chapters on organic chemistry contain content information in sections called "Get the Facts" (Figure 6.3)

GET THE FACTS

Oxidation of ethanol

- For the previous investigation, the colour change would be as shown in this table, depending on which solution you used.
- The product in the reaction between an oxidising agent and an alcohol is an organic acid.
- The smell of vinegar indicates the acid called ethanoic acid (acetic acid).

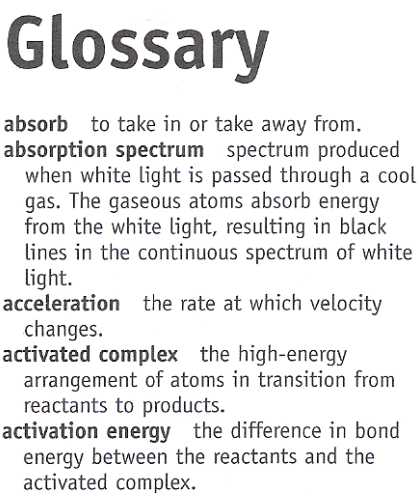
Solution	Colour before the reaction	Colour during and after the reaction
$K_2Cr_2O_7$	Orange ($Cr_2O_7^{2-}$ ion)	Green (reduced to Cr^{3+} ion)
$KMnO_4$	Purple (MnO_4^- ion)	Colourless (Mn^{2+} ion)

Figure 6.3 Get the facts

The learners' textbook covers the grade 12 work only. The learner's textbook is divided into six modules:

- Mechanics
- Waves; Sound and Light
- Electricity and Magnetism
- Matter and Materials
- Chemical Change
- Chemical Systems

Each module in the book is divided into sections which are further divided into units. A unit covers a specific topic and contains questions the learner should be able to answer at the end of the unit covering the main ideas within the unit (Figure 6.5); a statement of the skills that the learner will practise in the unit; explanations of key concepts (Figure 6.); practical investigations (Investigate it now activities), further exploration of the topic or extension information (Take it further) and assessment tasks which may be assignments, case studies, practical investigations and research projects. A glossary is also provided at the end of the book. New words appear in bold the first time they are used in the text and can be found in the glossary.

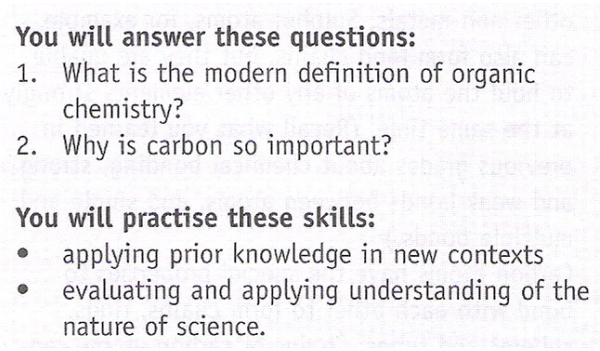


Glossary

absorb to take in or take away from.
absorption spectrum spectrum produced when white light is passed through a cool gas. The gaseous atoms absorb energy from the white light, resulting in black lines in the continuous spectrum of white light.
acceleration the rate at which velocity changes.
activated complex the high-energy arrangement of atoms in transition from reactants to products.
activation energy the difference in bond energy between the reactants and the activated complex.

Figure 6.3 Glossary Physical Sciences Explained

Figure 6.4 below shows a typical introduction to a unit in this book. The authors inform the learners what they should know at the end of the unit and what skills they will develop. e.g. “Why is carbon important? and “applying prior knowledge in new contexts” Learning Outcomes and assessment standards are not indicated to the learners.



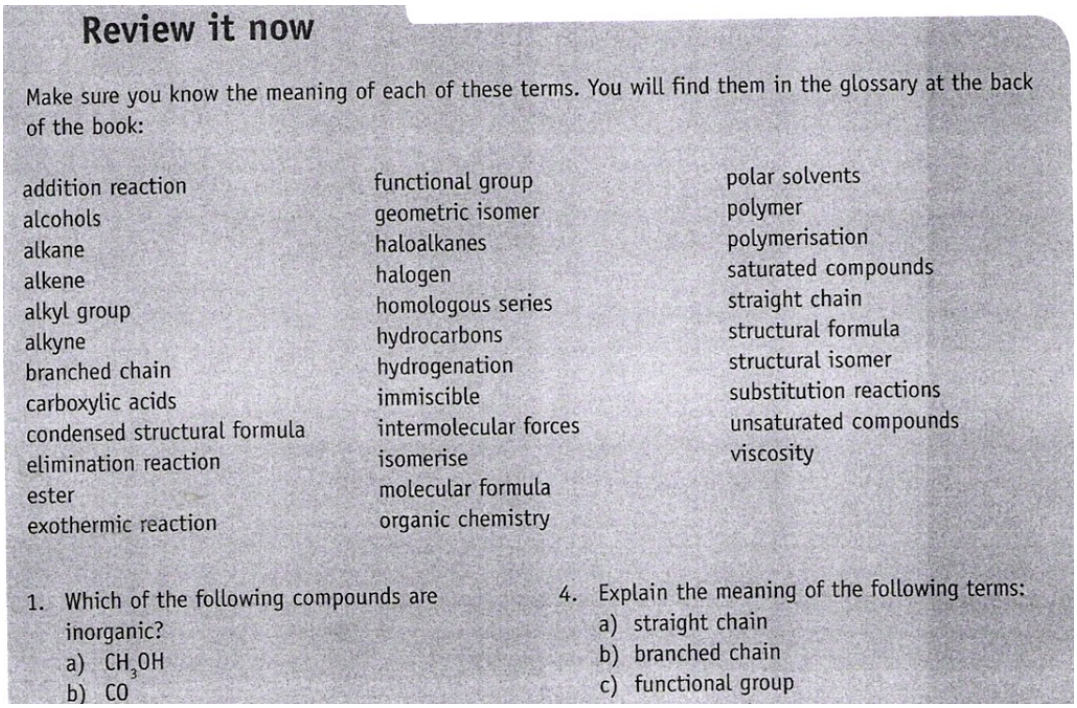
You will answer these questions:
1. What is the modern definition of organic chemistry?
2. Why is carbon so important?

You will practise these skills:
- applying prior knowledge in new contexts
- evaluating and applying understanding of the nature of science.

Figure 6.4 Page 147 Physical Sciences Explained

Although a summary is not available to the learners, an activity called “Review it now” (Figure 6.5) is present at the end of the section in the textbook. In this activity the learner’s attention is drawn to the terms they should know and the fact that these terms can be found at the end of the book in the glossary. They are also given a

variety of questions which cover the different topics in the units on organic chemistry.



Review it now

Make sure you know the meaning of each of these terms. You will find them in the glossary at the back of the book:

addition reaction
alcohols
alkane
alkene
alkyl group
alkyne
branched chain
carboxylic acids
condensed structural formula
elimination reaction
ester
exothermic reaction
functional group
geometric isomer
haloalkanes
halogen
homologous series
hydrocarbons
hydrogenation
immiscible
intermolecular forces
isomerise
molecular formula
organic chemistry
polar solvents
polymer
polymerisation
saturated compounds
straight chain
structural formula
structural isomer
substitution reactions
unsaturated compounds
viscosity

1. Which of the following compounds are inorganic?
   a) CH_3OH
   b) CO

4. Explain the meaning of the following terms:
   a) straight chain
   b) branched chain
   c) functional group

Figure 6.5 Review it now

The reading level of the chapter is appropriate for the level or grade being taught. I used two paragraphs chosen at random in the chapter and used the Flesch Kincaid Reading Ease Test contained within Microsoft Word 2007 to see if the reading level was appropriate. The grade level for this textbook was found to be 7.4 in one paragraph and 12.8 in another. Although this is appropriate for grade 12 there is a large discrepancy in the level. In general the language is fairly simple and appears to be appropriate for second language learners.

To check whether the size and format of the print was appropriate; I measured the approximate print size from the bottom of the lowest descender to the top of the highest ascender. This value was then converted to points in the Pica system which is used in the USA and the UK using the conversion 1pt=0.3614mm. The headings and text in this book ranged from +/- 11pt to +/- 32 pt. The general guideline for printed text is to use between 11 and 14 point font regardless of the audience and this appears to be the most common size for print in most media. The main headings in this book were very large and eye catching while most of the text was 12pt. The

way in which the text is set out is visually appealing and important information is bulleted to make it easier for the learners to read and understand.

The format of the book is visually appealing and interesting. The information is presented by the authors in many ways for example pictures (Figure 6.6), textboxes, diagrams (pg 148), structural formulae (pg 148), mind maps (pg 150), tables (pg 152), worked examples (pg 159 & 161) and real life examples (pg 167). The information presented is all appropriately and correctly referenced with the text. However as can be seen from the picture in Figure 6.6 the simplistic nature of the picture shows very poor use of scale as the banana, chicken and the cow appear to be similar in size.

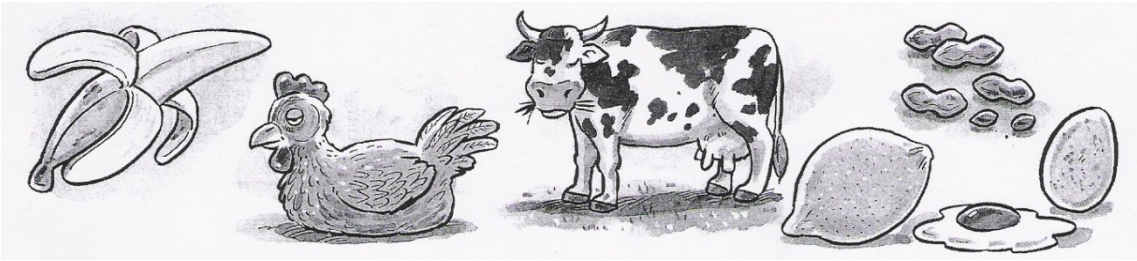


Figure 6.6 Picture from Physical Sciences Explained showing sources of carbon

6.1.2 THE TEACHER'S GUIDE

The Teacher's Guide has detailed support and gives special attention to helping educators with OBE assessment. It includes assessment rubrics for every activity.

The Teacher's Guide follows a similar format to the learner's book and is divided into two sections: Part A and Part B. Part A concerns the National Curriculum statement and the role of physical sciences in the NCS. It looks at the learning outcomes and assessment standards and their relationship with critical and developmental outcomes and provides the teacher with a variety of assessment rubrics for various activities.

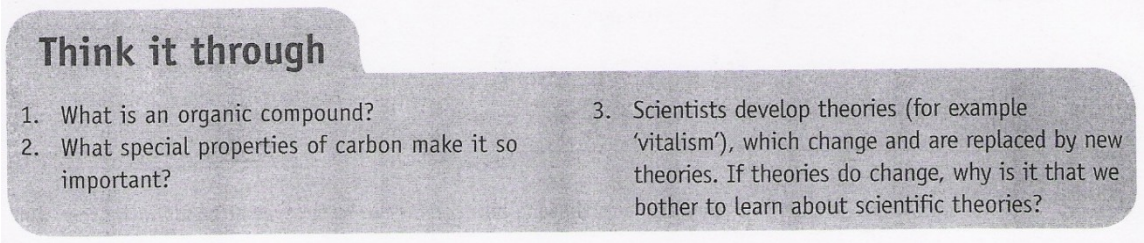
In Part B, chapter 1 the structure of the book is explained and indicates clearly whether the content is core content or optional content. This section indicates which learning outcomes and assessment standards have been used in each section of the

book. Examples of work schedules, lesson plans and programmes of assessment are also provided for the teacher.

In chapter 2 step by step guidance is provided for implementing this learning programme in the classroom by providing an overview which is meant to alert the teacher to any difficult content issues and provides suggestions for dealing with challenging concepts, lists of outcomes and assessment standards and answers to questions within the unit as well as ideas and suggestions for assessing the work done by the learners and exemplar rubrics.

In the unit on carbon in organic compounds the teacher is encouraged to give a historical background to organic chemistry and to use models to illustrate bond formation, and straight and branched structures.

Each activity in the unit comes with detailed answers and suggestions. An example of this is where learners are given an opportunity to demonstrate their prior knowledge. This is an example of the authors' PCK.


Think it through

1. What is an organic compound?
2. What special properties of carbon make it so important?
3. Scientists develop theories (for example 'vitalism'), which change and are replaced by new theories. If theories do change, why is it that we bother to learn about scientific theories?

Figure 6.7 Example of encouraging learner's to access prior knowledge

The Teacher's Guide suggests the importance of making sure that the learners understand the difference between organic and inorganic compounds. The second question allows the learners to demonstrate prior knowledge about carbon. In grades 10 and 11 learners should have been taught about how carbon bonds, the shapes of molecules such as methane etc. The third question encourages a discussion on the importance of scientific theories. A detailed analysis of scientific theories is given in the Teacher's Guide to help the teachers lead a discussion on this with their learners. The importance of the learners' prior knowledge of inter-

molecular forces as well as the reactions from grade 11 i.e. substitution, addition and elimination are also brought to the teacher's attention by the authors.

The authors encourage teachers to explain to their learners how to use concept maps. The authors indicate that these maps are useful tools for learners to summarise and understand the information in the section.

The use of models to help learners to classify and name compounds is also emphasized in the Teacher's Guide. The authors also indicate that learners will have to learn (memorise) the rules of the system of naming organic compounds (IUPAC) and will need to be able to identify patterns to successfully identify to which homologous series the compound belongs. The authors also encourage the teachers to allow enough time for the learners to practise these skills.

6.2 MEDIATION OF CHEMISTRY CONTENT.

A CoRe was developed for the unit, to try to identify how the authors of the textbook mediated the organic chemistry content for teaching and learning. Five different Big Ideas were identified from the five units in this section. They are:

- Carbon has special properties which make it unique.
- Organic compounds are classified according to their bonds or structures.
- Organic compounds are named and represented according to IUPAC rules.
- Organic compounds have distinctive physical properties.
- Reactions that organic substances undergo are determined by chemical properties.

6.2.1 The CoRe: CONTENT REPRESENTATION

The CoRe below was developed using the five big ideas outlined above using the method that is described in detail in chapter 4. It was used to try to uncover and portray the PCK used by the authors of the textbook. Their use of tables, in-chapter exercises etc are their expression of the content and their way of conveying the content to the learners.

In this textbook the authors had clearly divided the topic into five main ideas which were placed into 5 separate units and these were left as the authors had separated them in the CoRe.

The topics although linked to both content covered in previous grades and the other topics within the section were self contained and dealt with in a logical, easy to follow format.

Table 6.2 Big Ideas 1&2 Physical Sciences Explained

BIG IDEA/PROMPTS	BIG IDEA 1: CARBON HAS SPECIAL PROPERTIES WHICH MAKE IT UNIQUE	BIG IDEA 2: ORGANIC COMPOUNDS ARE CLASSIFIED ACCORDING TO THEIR BONDS OR STRUCTURES.
1 What do you intend your learners to learn about this idea?	The modern definition of organic chemistry. The importance of carbon. The history of organic chemistry Understanding of carbon bonds Sources of organic compounds	Classification of organic compounds; Aliphatic hydrocarbons- saturated and unsaturated Alkanes-structural formulae; condensed formulae, homologous series; molecular formulae; names, structural isomers, differences in boiling and melting points; general formula; Alkenes and alkynes general formulas; unsaturated hydrocarbons; Straight and branched chains; alkyl groups; Hydrocarbon derivatives and families- structural characteristics and examples- alcohols, ethers. Aldehydes etc.; functional groups
2 Why is it important for the learners to know this?	Learners will be applying prior knowledge to new contexts. Evaluating and applying understanding of the nature of science.	What are saturated and unsaturated compounds? What is a functional group? The learners will be recalling important information, classifying objects and applying knowledge.
3 What else do you know that the learners do not need to know yet?	Classification of organic compounds; Aliphatic hydrocarbons-saturated and unsaturated Alkanes-structural formulae; condensed formulae, homologous series; molecular formulae; names, structural isomers, differences in boiling and melting points; general formula; Alkenes and alkynes general formulas; unsaturated hydrocarbons; Straight and branched chains; alkyl groups; Hydrocarbon derivatives and families- structural characteristics and examples- alcohols, ethers. Aldehydes etc.; functional groups	Rules for naming organic compounds; IUPAC nomenclature; writing IUPAC names; and substituent groups;
4 Difficulties/limitations connected with teaching this idea?	Lack of prior knowledge Difficulties learners have with concepts such as valency, electronic configuration Difficulties learners have with drawing Lewis and Couper diagrams, understanding of covalent bonding, VSEPR etc	New content- not covered previously and not similar to any other section.
5 Knowledge about the learners thinking which might influence your teaching of this idea?	Learners have little knowledge about carbon compounds Importance of the section in society as well as how much this section counts in the final examination.	Concept maps and diagrams will help illustrate ideas to the learners Learners need to practice the knowledge they have recently gained to reinforce it. Tables can show a lot of information clearly and logically
6 Teaching procedures and reasons for using these to engage the idea?	Historical perspective- synthesis of urea and theory of vitalism. Modern perspective- plastics, dyes, synthetic and natural fibres etc. Think it through-in chapter exercises for learners Pictures- stylized to emphasize variety of foodstuffs where carbon is found- uses of hydrocarbons as fuels. Structural formulae shown (Couper structure) - straight chains, branched structures and ring structure. Practise it now- in chapter exercises. Investigate it now- assessment task-to involve learners in working together in groups; collecting and collating information; following steps to complete a task with given criteria. Get the facts- new facts- content AUFBAU diagram for carbon in ground state and excited state.	Concept map of classification of organic compounds Think it through- in chapter exercise for learners Ball and stick diagrams showing 3-D nature of structures Get the facts- new facts- content Table showing alkanes with number of carbons, condensed formulas and the meaning of the prefixes/ table showing alkyl group structure and alkyl group name./ table showing hydrocarbon derivatives, structural characteristics and examples of each derivative/table showing group names, examples, structural formulae and functional groups/ Couper structures showing isomers Practise it now- in chapter exercises. Investigate it now- task designed to allow learners to practice drawing structural formulae, name compounds and derive a general formula for the compounds.

BIG IDEA/ PROMPTS	BIG IDEA 3: ORGANIC COMPOUNDS ARE NAMED AND REPRESENTED ACCORDING TO IUPAC RULES	BIG IDEA 4: ORGANIC COMPOUNDS HAVE DISTINCTIVE CHEMICAL PROPERTIES.
1 What do you intend your learners to learn about this idea?	Rules for naming organic compounds; IUPAC nomenclature; writing IUPAC names; and substituent groups;	Liquefied alkanes as fuels; (leaded and unleaded fuels) and additives to petrol General properties- intermolecular forces, polarity; solubility; uniqueness of carbon, rate of reaction, large number of by-products, long chains. Organic reactions are non- stoichiometric; Properties of alkanes- as fuels; density; non-polar; combustion produces mainly carbon dioxide and water; melting and boiling points Alkenes (olefins); made by cracking alkanes; similar physical properties, solubility, density; double bonds and geometric isomers; (cis and trans butene) Alkynes- triple bonds; boiling and melting points, densities, solubility, Aromatic hydrocarbons;- smell; structure (benzene ring); stability, carcinogenic properties, reactions of aromatics-hydrogen atom substitution
2 Why is it important for the learners to know this?	What system is used to name organic compounds? Why is it so important to use rules? (Understanding why it important to have and keep rules and why these rules relate to a model.) Applying rules in naming organic compounds and communicating your ideas to others	What properties do aliphatic organic compounds have? How useful or harmful are organic compounds in society? Applying knowledge; comparing reactions; kinds of products produced, comparing properties of compounds and drawing conclusions.
3 What else do you know that the learners do not need to know yet?	Liquefied alkanes as fuels; (leaded and unleaded fuels) and additives to petrol General properties- intermolecular forces, polarity; solubility; uniqueness of carbon, rate of reaction, large number of by-products, long chains. Properties of alkanes- as fuels; density; non-polar; combustion produces mainly carbon dioxide and water; melting and boiling points Alkenes (olefins); made by cracking alkanes; similar physical properties, solubility, density; double bonds and geometric isomers; (cis and trans butane) Alkynes- triple bonds; boiling and melting points, densities, solubility, Aromatic hydrocarbons;- smell; structure (benzene ring); stability, carcinogenic properties, reactions of aromatics-hydrogen atom substitution	Reactions of hydrocarbons –grade 12
4 Difficulties/limitations connected with teaching this idea?	New knowledge for learners to absorb. Many rules to follow correctly	Understanding of intermolecular forces is weak; large amount of content to be learned
5 Knowledge about the learners thinking which might influence your teaching of this idea?	Learners need to remember rules Learners need to practise with many example to master the skills Learners need examples to help them understand new concepts.	Learners struggle with the concept of intermolecular forces and shapes of molecules (revision has been included) Tables allow easy presentation of large amounts of data
6 Teaching procedures and reasons for using these to engage the idea?	❖ Cartoon to illustrate the need for rules ❖ Get the facts- new content ❖ Table containing info on alkanes, alkenes and alkynes and their substituent (alkyl) groups ❖ Structural formulae (Couper structure} ❖ Worked examples for teachers/learners to use. ❖ Practise it now- in chapter exercise/ end of chapter exercise.	Pictures (cigarette lighter) –portable fuel supply Revision of intermolecular forces Tables- molecular structure/boiling and melting points/phase-alkanes; alkynes and alkenes Content – Get the facts;Practise it now- understanding alkanes, alkenes and alkynes;Science in our world- leaded and unleaded petrol Couper diagrams,Comprehension- Petrol; additives Think it through- in chapter exercise

Table 6.3 Big Ideas 3&4 Physical Sciences Explained

Table 6.4 Big Idea 5 Physical Sciences Explained

	BIG IDEA/PROMPTS	BIG IDEA 5: REACTIONS THAT ORGANIC SUBSTANCES UNDERGO ARE DETERMINED BY THE CHARCTERISTIC CHEMICAL PROPERTIES.
1	What do you intend your learners to learn about this idea?	Addition, elimination and substitution reactions; Reactions of alkanes- substitution- formation of Haloalkanes (alkyl halides) – reactions required light energy; Oxidation reactions –combustion- exothermic; Elimination reactions- cracking, dehydration etc ; Reactions of alkenes and alkynes- Addition e.g. hydrogenation; addition polymerization; production of poly-ethene; using ethene and production of ethene; Addition reactions of alkynes; Hydrocarbon derivatives- alcohols- properties, functional group; polarity; alcohols as solvents; production of methanol; properties of methanol (poisonous); production of ethanol- oxidation to ethanoic acid or ethanol with potassium dichromate; ethanol in alcohol drinks, as a solvent; Glycerol- (glycerine)- lubricant and moistening agent; properties-viscosity and degree of hydrogen bonding.; elimination reactions of alcohols- loss of water- dehydration of alcohols; Carboxylic acids (carboxyl group)- preparation of carboxylic acids; oxidation of ethanol to ethanoic acid; weak aids and dissociation; solubility; ethanoic acid in vinegar and use in production of artificial fibres.; Esters- produced from reaction between alcohol and carboxylic acid; pleasant smells (used in synthetic scents); important esters- animal and vegetable fats are esters of long chain fatty acids; reactions with sodium hydroxide splits fat into glycerol and sodium salt-(production of soap); Soaps and detergents.
2	Why is it important for the learners to know this?	Which types of reaction apply to organic substances? Identifying types of reactions and reaction sites; comparing reactivity of organic compounds, what determines the type of reaction, which organic substances are very reactive
3	What else do you know that the learners do not need to know yet?	Plastics, polymers, organic macro-molecules, biological macro-molecules; processing crude oil; Sasol process
4	Difficulties/limitations connected with teaching this idea?	Large amount of content; Conceptual understanding
5	Knowledge about the learners thinking which might influence your teaching of this idea?	Learners find identifying reactions and reaction sites difficult; learners struggle with concept of intermolecular forces, bonding and find comparing reactivity difficult.
	6. Teaching procedures and reasons for using these to engage the idea?	Pictures- oxyacetylene torch; uses of alcohol; perfumes; wine; Get the facts-content ;Think it through- in chapter exercise; Equations-showing different types of reactions; Structural formulae; Science in our world- ethene in plants life cycle- in chapter exercise and practical on ripening of fruit Practise it now- in chapter exercise; Investigate it now- Practical on oxidizing ethanol; reactions with carboxylic acids; reactions with metals; neutralizing reactions and with sodium carbonate; Review it now- end of section exercise

6.2.2 BIG IDEA 1 CARBON HAS SPECIAL PROPERTIES WHICH MAKE IT UNIQUE

The author intends the learners to understand the modern definition of organic chemistry; the importance of carbon; the history of organic chemistry; different sources of organic compounds and have an understanding of carbon bonds.

The teaching procedures used for teaching this idea are:

- Giving the learners a historical perspective using the synthesis of urea and the theory of vitalism[1]. This allows the learners to realize that historically scientific thinking was that organic compounds could only be formed from living matter.
- The in chapter exercise 'Practise it now' requires to learners to answer why such a large number of organic compounds exists, how organic compounds store energy (fossil fuels) and to list at least 10 organic compounds that are around them.
- Giving the learners a modern perspective using the synthesis of plastics, dyes and synthetic and natural fibres. This includes making organic substances from inorganic substances synthetically in 1828 by a German chemist Friedrich Wöhler[2].
- The 'Think it Through' in chapter exercises requires the learners to focus on the properties of carbon that make it different from other elements
- Pictures (Figure 6.8) which have been stylised to attract the learners attention and to emphasize the importance and uses of carbon compounds especially as fuels.

[1] The theory or doctrine that states that life processes arise from or contain a nonmaterial vital principle and which cannot be explained entirely as physical and chemical phenomena. www.thefreedictionary.com/**vitalism**
A doctrine that the processes of life are not explicable by the laws of physics and chemistry alone and that life is in some part self-determining. www.merriam-webster.com/dictionary/**vitalism**
[2] The synthesis of urea from ammonium cyanate disproved the vitalism theory.

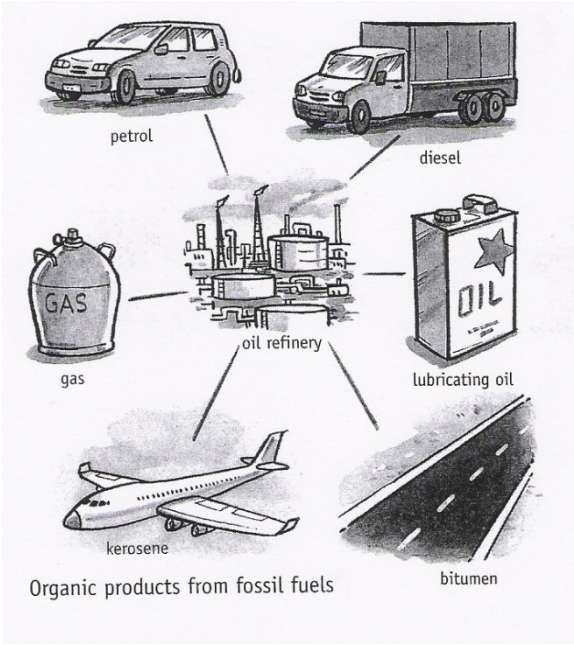


Figure 6.8 Organic products from fossil fuels

- The structural formulae shown highlight the different structures of organic compounds i.e. straight chains, branched structures and ring structures.

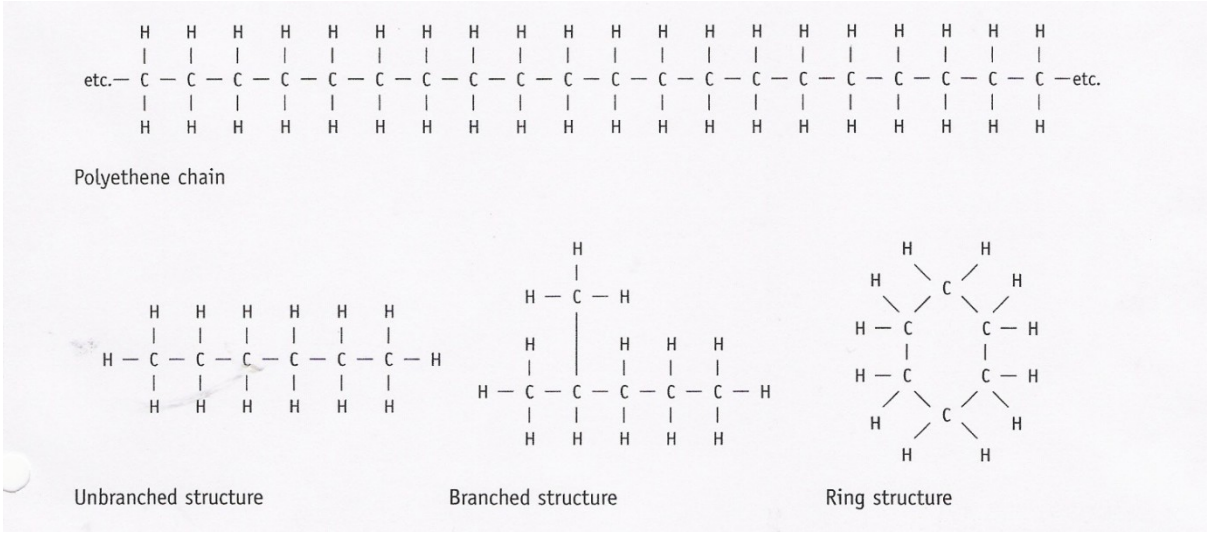


Figure 6.9 Different carbon structures

- 'Investigate it now' is an assessment task designed to involve learners in working together in groups; collecting and collating information; following steps to complete a task with given criteria.

- 'Get the facts' provides the learners with new facts on the organic chemistry content i.e. that photosynthesis is the main source of organic compounds and how carbon atoms have the ability to form strong covalent bonds with other carbon atoms as well as other non-metals (Figure 6.11).

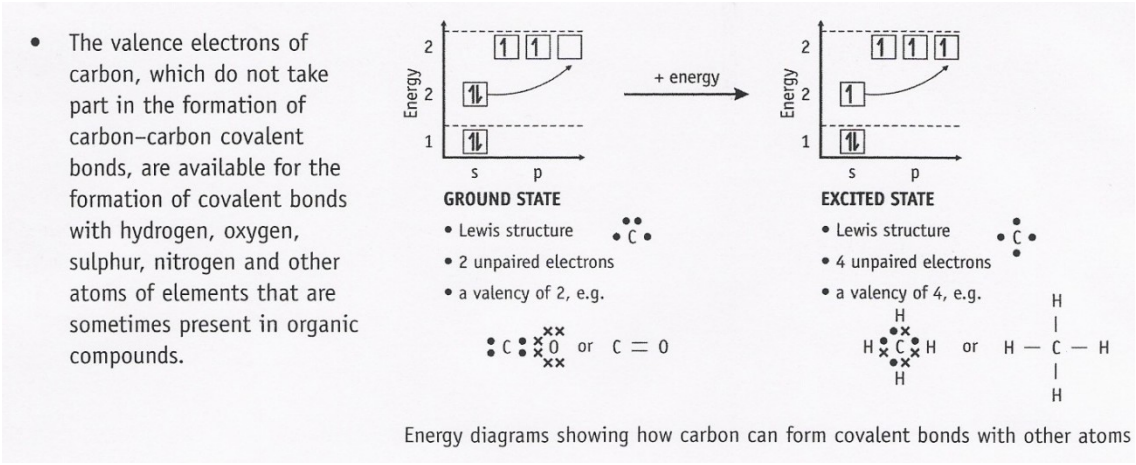
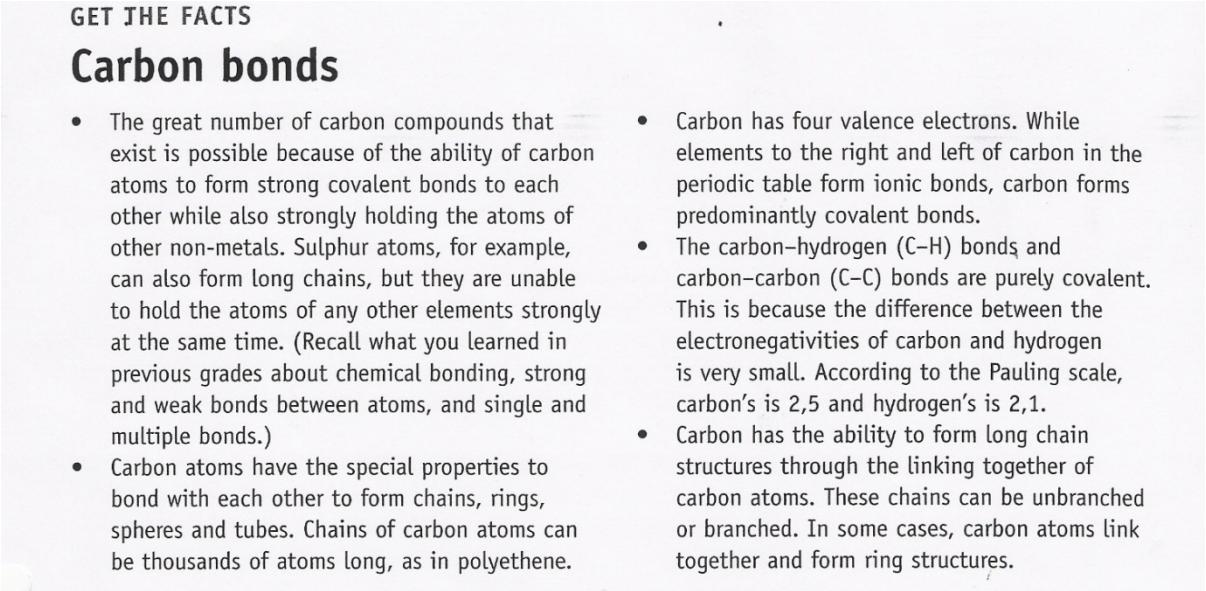


Figure 6.10 Aufbau Diagrams[3] for carbon in its ground and excited state.

- The use of the AUFBAU diagram (Figure 6.10) for carbon in ground state and excited state is revision of grade 11 chemistry and shows that the authors are aware of the importance of prior knowledge


GET THE FACTS

Carbon bonds

- The great number of carbon compounds that exist is possible because of the ability of carbon atoms to form strong covalent bonds to each other while also strongly holding the atoms of other non-metals. Sulphur atoms, for example, can also form long chains, but they are unable to hold the atoms of any other elements strongly at the same time. (Recall what you learned in previous grades about chemical bonding, strong and weak bonds between atoms, and single and multiple bonds.)
- Carbon atoms have the special properties to bond with each other to form chains, rings, spheres and tubes. Chains of carbon atoms can be thousands of atoms long, as in polyethene.
- Carbon has four valence electrons. While elements to the right and left of carbon in the periodic table form ionic bonds, carbon forms predominantly covalent bonds.
- The carbon–hydrogen (C–H) bonds and carbon–carbon (C–C) bonds are purely covalent. This is because the difference between the electronegativities of carbon and hydrogen is very small. According to the Pauling scale, carbon's is 2,5 and hydrogen's is 2,1.
- Carbon has the ability to form long chain structures through the linking together of carbon atoms. These chains can be unbranched or branched. In some cases, carbon atoms link together and form ring structures.

Figure 6.11 Facts about carbon and how it bonds.

[3] These are diagrams that show the electrons in the energy levels of the various atomic orbitals for each element or ion.

6.2.3 BIG IDEA 2: ORGANIC COMPOUNDS ARE CLASSIFIED ACCORDING TO THEIR BONDS OR STRUCTURES.

In this big idea the authors deal with the classification of organic compounds into aliphatic, cyclic ring structures and acyclic structures which can be saturated and unsaturated (straight chains and branched chains) and aromatic hydrocarbons (organic molecules containing a benzene ring[4]), To do this they use structural formulae, condensed formulae, molecular formulae, general formulae, the concepts of the homologous series (families with the same structural characteristics), names of organic compounds, isomers, functional groups and differences in boiling and melting points.

The teaching ideas used by the authors in this big idea include:

- The diagram (Figure 6.12) showing the classification of organic compounds which allows the learners to see a larger picture of how organic compounds are classified. The authors refer to this as a concept map but it contains no linking words to help the learners understand the concepts.

[4] A hexagonal ring arrangement found in benzene and other aromatic compounds, consisting of six carbon atoms with alternating single and double bonds between them, and with each carbon atom bonded to a hydrogen atom, or to other atoms or groups of atoms in derivatives of benzene.

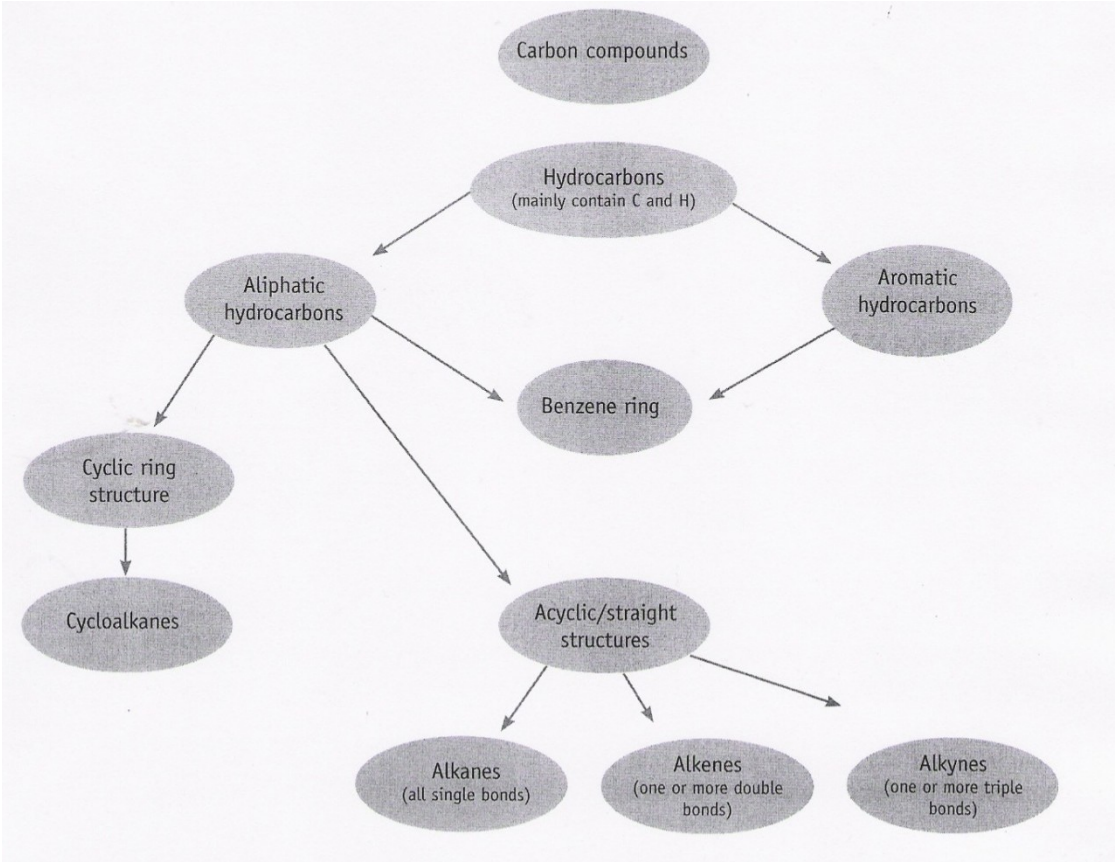


Figure 6.12 Mind map of classification of organic compounds[5]

- In the 'Think it through' in chapter exercise the learners are asked study the concept map and consider other ways of classification.
- It is important that learner understand the three dimensional nature of organic molecules. The Ball and stick diagrams show the 3-D nature of organic structures and give the learners a comparison with the 2-D structures shown in structural formulae. These types of multiple representations are an important example of the authors' PCK as learners have to be able to recognise different representations of the same structures.

[5] The link between Aliphatic hydrocarbons and the benzene ring is questionable.

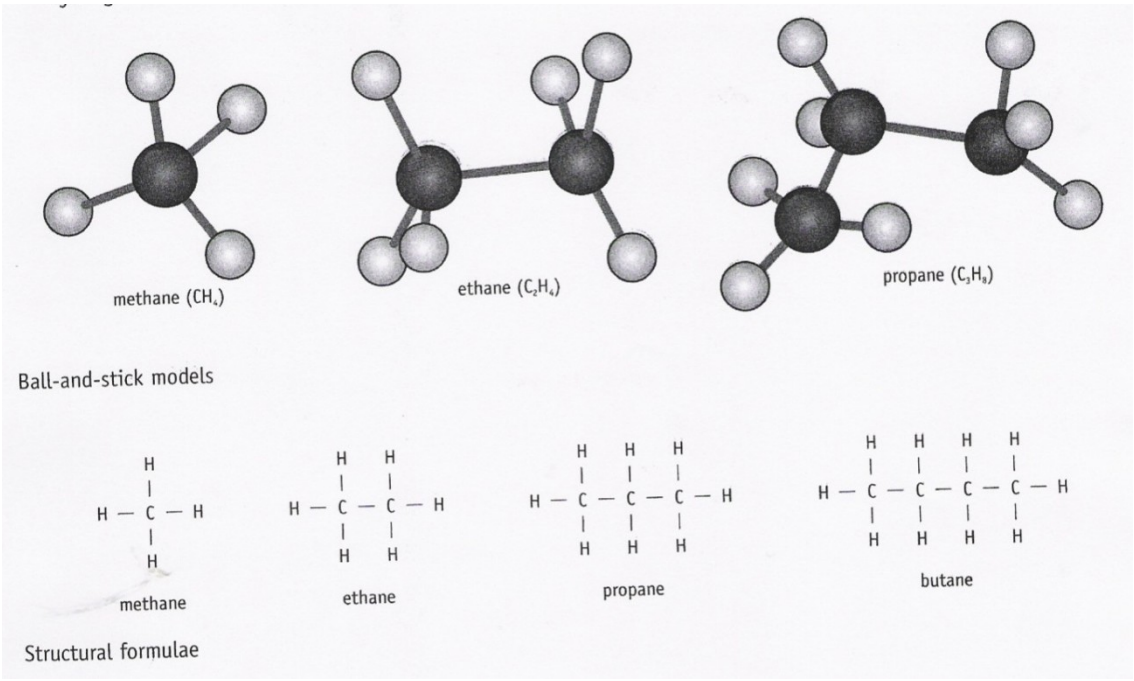


Figure 6.13 Ball and Stick models and structural formulae

- The authors present new information in sections with the heading 'Get the facts'. In this big idea the authors have used tables to present new information about alkanes i.e. name, number of carbons, condensed formulas, the meanings of the prefixes, alkyl group structure and alkyl group name, hydrocarbon derivatives, structural characteristics and examples of each derivative and functional groups. These tables allow the data that might not be easily understood to be presented to the learners in a way that communicates the information in a clear and accessible way.

Alkane name	No. of carbons	Condensed formula	Prefix meaning
Pentane	5	$CH_3(CH_2)_3CH_3$	'pent-' means five
Hexane	6	$CH_3(CH_2)_4CH_3$	'hex-' means six
Heptane	7	$CH_3(CH_2)_5CH_3$	'hept-' means seven
Octane	8	$CH_3(CH_2)_6CH_3$	'oct-' means eight
Nonane	9	$CH_3(CH_2)_7CH_3$	'non-' means nine
Decane	10	$CH_3(CH_2)_8CH_3$	'dec-' means ten

Figure 6.14 Table relating names, numbers of carbons, condensed formulae and prefixes

- Couper structures have been used to show the difference between isomers such as 1-butene and 2-butene. This allows the learners to see the difference in the positions of the double bond.
- The in chapter exercises 'Practise it now' allows the learners to practise defining concepts, giving general formulae, writing condensed structures and using structural formulae to illustrate isomers.
- 'Investigate it now' is a task designed to allow learners to practice drawing structural formulae, name compounds and derive a general formula for the compounds.

6.2.4 BIG IDEA 3: ORGANIC COMPOUNDS ARE NAMED AND REPRESENTED ACCORDING TO IUPAC RULES.

In this big idea the learners are expected to know the rules for naming organic compounds, IUPAC nomenclature as well as how to write IUPAC names and substituent groups as prefixes and suffixes.

The teaching ideas used by the authors in this unit are:

- The authors use a cartoon (Figure 6.15) to illustrate the need for rules to demonstrate how confusion would exist without the rules. This shows that the authors understand the need to engage the learners with the topic. The cartoon uses black learners and a girl to illustrate the need for the rules to name organic compounds. Traditionally both of these groups have been excluded from science textbooks and science education in general. The cartoon illustrates the authors' PCK while addressing the whole point of the Big Idea. The learners will associate a cartoon with something that is attractive and enjoyable and this will motivate them to learn.

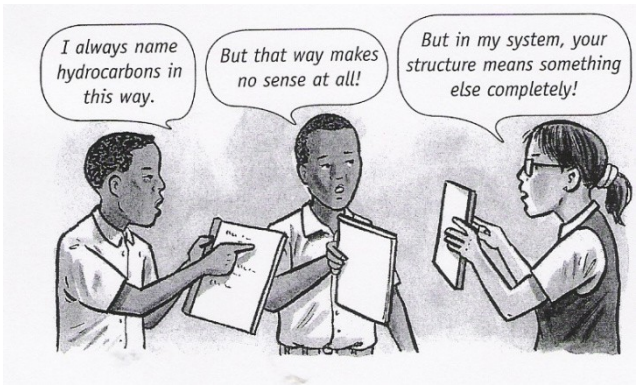


Figure 6.15 Cartoon about the importance of rules

- The rules and method for naming organic compounds are set in 'Get the facts' (new content). The authors show the learners in bulleted and numbered steps what the rules are and how they should be used.
- A table containing information on alkanes, alkenes and alkynes and their substituent (alkyl) groups illustrates to the learners the patterns that exist in the naming of organic compounds.
- Structural formulae (Couper structures) are used by the authors to demonstrate how the learners should number the carbons in the longest chain in order to name the compound correctly (Figure 6.16) illustrating content PCK.

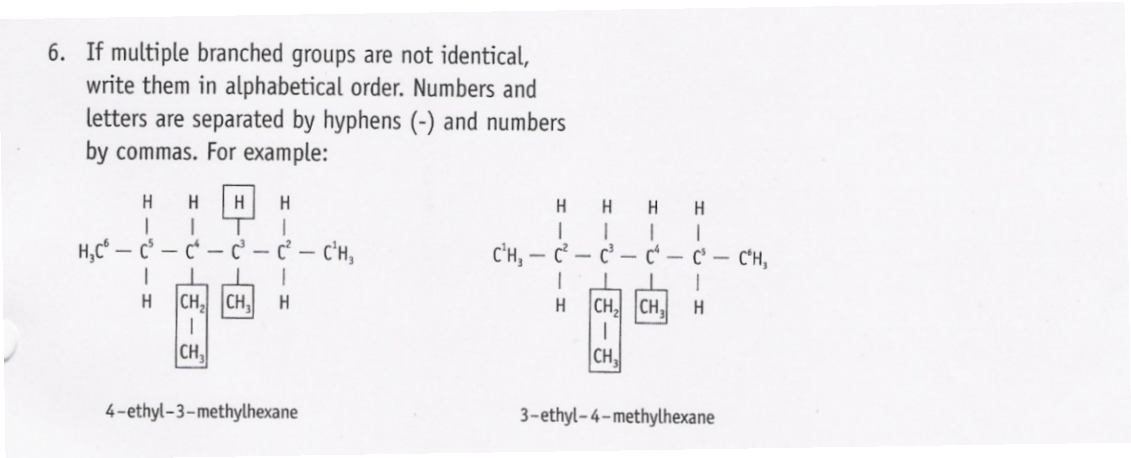


Figure 6.16 Example to show how multiple groups would be numbered and named

- In the worked examples (Figure 6.17) provided, teachers and learners can see exactly how to answer a question on naming an organic compound using IUPAC rules.

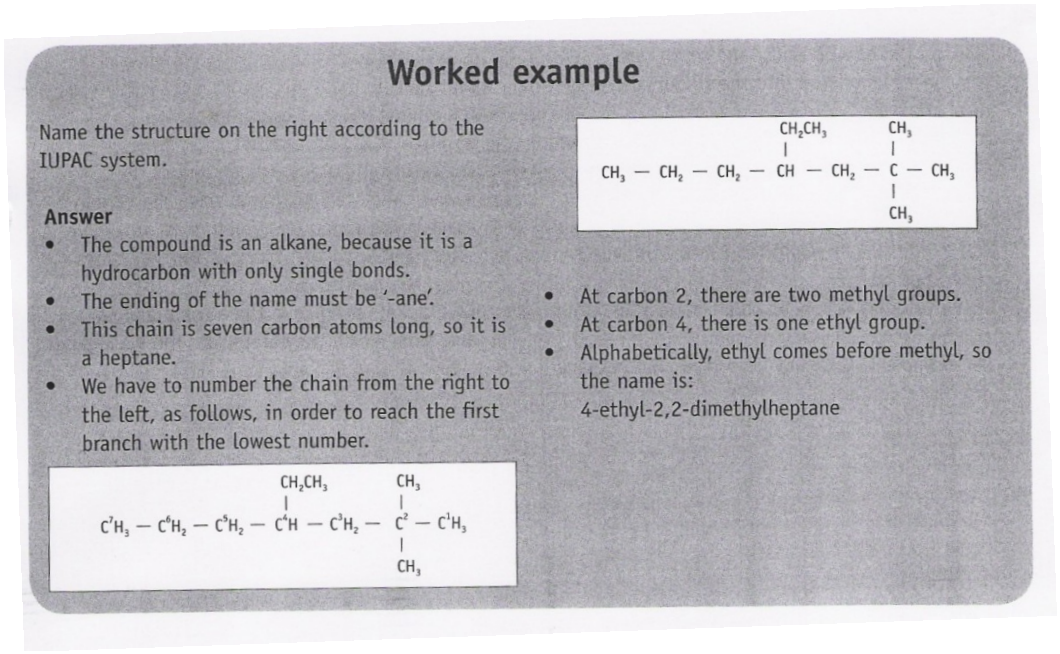


Figure 6.17 Worked examples on naming organic compounds

- The 'Practise it now' in chapter and end of chapter exercises give the learners practise with naming and drawing structures.

6.2.5 BIG IDEA 4: ORGANIC COMPOUNDS HAVE CHARACTERISTIC PHYSICAL PROPERTIES.

In this big idea the authors show it is important that the learners link the physical properties of organic compounds with their uses. An example of this is liquefied alkanes being used as fuels for cars, trucks etc.

These properties such as density, melting and boiling points, vapour pressure, polarity, viscosity, solubility, types of intermolecular forces, degree of saturation can change with increasing mass and chain length and type of functional group.

The authors have used the following teaching ideas in this unit:

- Pictures (Figure 6.18) have been used to illustrate the everyday uses and properties of alkanes such as butane as a fuel in a portable appliance such as a cigarette lighter.

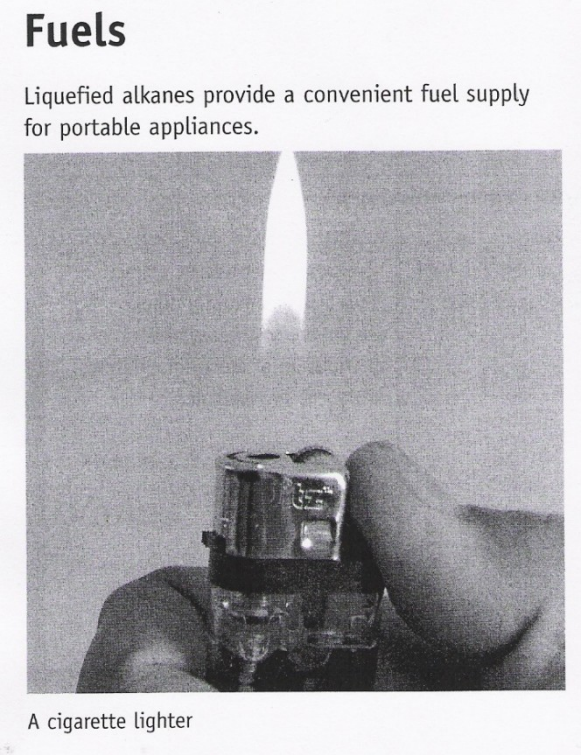
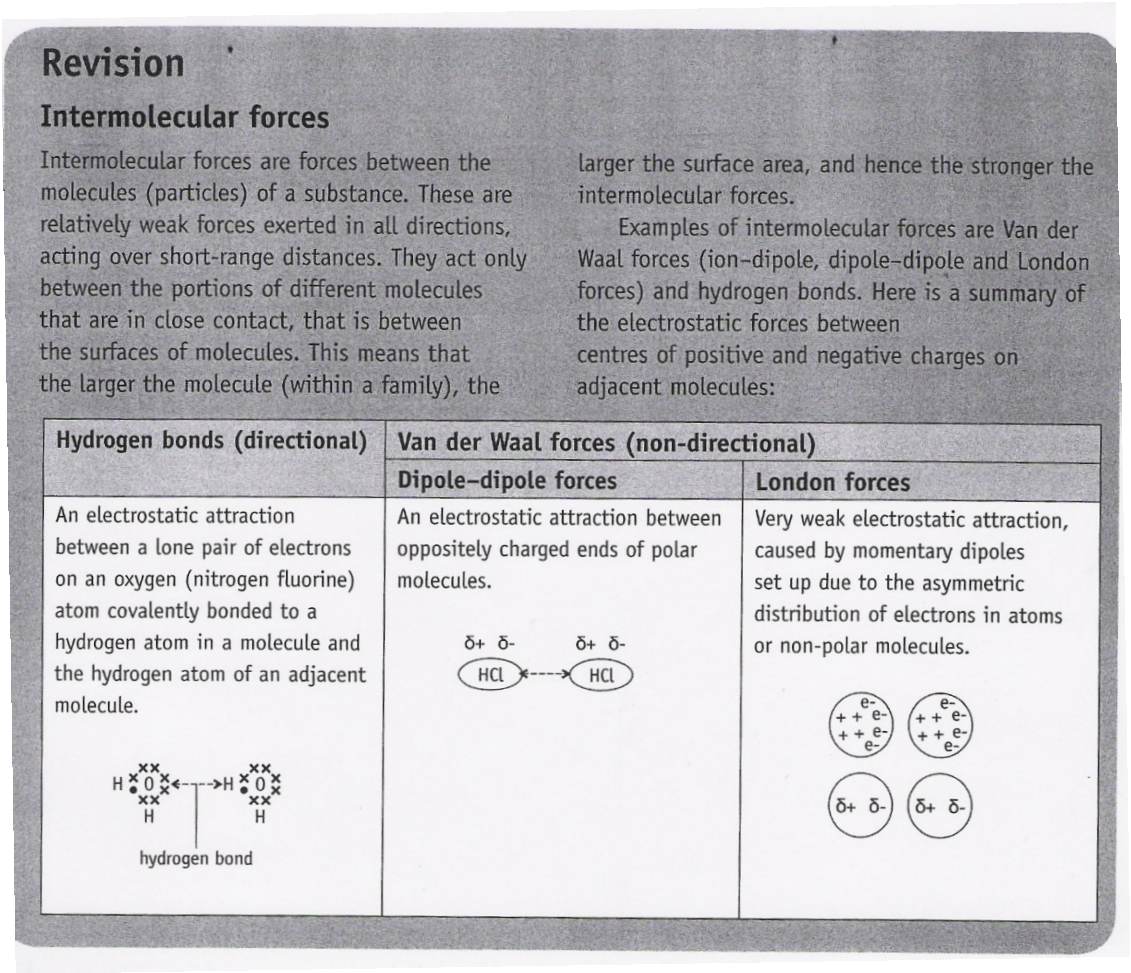


Figure 6.18 Butane as a convenient fuel supply for portable appliances

- The authors have recognised a need for the revision of intermolecular forces (Figure 6.19) which comes from the grade 11 chemistry curriculum. This shows multiple instances of PCK e.g. knowledge of learners and learning, knowledge of the curriculum and content knowledge. They have used a text box labelled revision which allows for the information to be accessed easily by the learners.
- Tables which show molecular structure; boiling and melting points and phases of alkanes, alkynes and alkenes have been used to show the learners how the intermolecular forces increase with increasing chain length and mass.
- The new content is shown in ‘ Get the facts’ in an accessible bulleted format which allows the learners to access the information easily.
- ‘Practise it now’ which is an in-chapter exercise designed to help the learners understand alkanes, alkenes and alkynes.

- The 'Science in our world' textbox gives the learners information on additives in fuels i.e. leaded and unleaded petrol and that petrol consists of a mixture of hydrocarbons of different chain lengths.



Revision

Intermolecular forces

Intermolecular forces are forces between the molecules (particles) of a substance. These are relatively weak forces exerted in all directions, acting over short-range distances. They act only between the portions of different molecules that are in close contact, that is between the surfaces of molecules. This means that the larger the molecule (within a family), the larger the surface area, and hence the stronger the intermolecular forces.

Examples of intermolecular forces are Van der Waal forces (ion–dipole, dipole–dipole and London forces) and hydrogen bonds. Here is a summary of the electrostatic forces between centres of positive and negative charges on adjacent molecules:

Hydrogen bonds (directional)	Van der Waal forces (non-directional)	
	Dipole–dipole forces	London forces
An electrostatic attraction between a lone pair of electrons on an oxygen (nitrogen fluorine) atom covalently bonded to a hydrogen atom in a molecule and the hydrogen atom of an adjacent molecule.	An electrostatic attraction between oppositely charged ends of polar molecules.	Very weak electrostatic attraction, caused by momentary dipoles set up due to the asymmetric distribution of electrons in atoms or non-polar molecules.

Figure 6.19 Revision of intermolecular forces

- Diagrams (Figure 6.20) have been used to illustrate to the learners the four different representations of benzene and how benzene can undergo substitution. It is important for the learners to recognise the same compounds represented in different ways and the authors' PCK is shown again in this multi-representation.

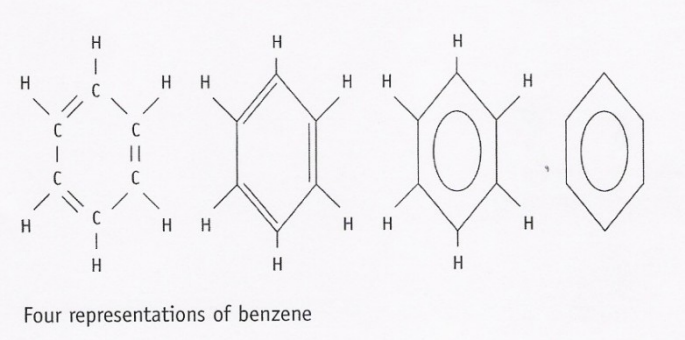


Figure 6.20 Different representations of benzene

- A comprehension on toxic additives has been included and this activity allows learners to express their own opinions about how for example the environment is being damaged and give the learner some more 'general' knowledge which relates to this section of chemistry.
- A 'Think it through' in chapter exercise allows the learners to relate fuels to their everyday lives and find other examples of fuels used in appliances.

6.2.6 BIG IDEA 5: REACTIONS THAT ORGANIC SUBSTANCES UNDERGO ARE DETERMINED BY THEIR CHARACTERISTIC CHEMICAL PROPERTIES.

In this big idea the authors introduce the learners to the different types of reactions that organic compounds can undergo and how these reactions are linked to the physical and chemical properties of the compounds. They expect that the learners will have covered some of the material in the grade 11 curriculum although they have included this material in the unit.

The different types of reactions substitution (reactions that require light energy), addition, (hydrogenation, polymerisation) elimination (cracking and dehydration) and oxidation (combustion) have been linked by the authors to functional groups, industrial production, properties and uses e.g. oxidation of ethanol to ethanoic acid and production of esters from alcohols and carboxylic acids.

They have also linked the information in this chapter to the section dealing with chemical systems and the production of soaps and detergents.

The following teaching ideas have been used in this unit:

- Pictures of an oxyacetylene torch and different uses of alcohol in everyday applications e.g. perfume, cough mixtures, cleaning agents, allows the learners to relate to how organic compounds react in an easy to understand way (Figure 6.21).

Figure 6.21 Pictures of different uses of alcohol

- The 'Get the facts' gives the learners the new content in an easily accessible way by bulleting the content.
- The 'Think it through' in chapter exercise allows the learner to focus on and recall work that was done in grade 11.
- Equations were used by the authors to show different types of reactions using chemical symbolism (Figure 6.22).

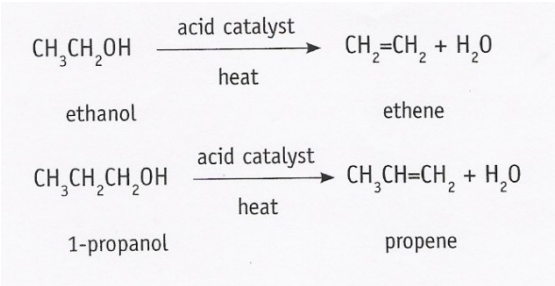
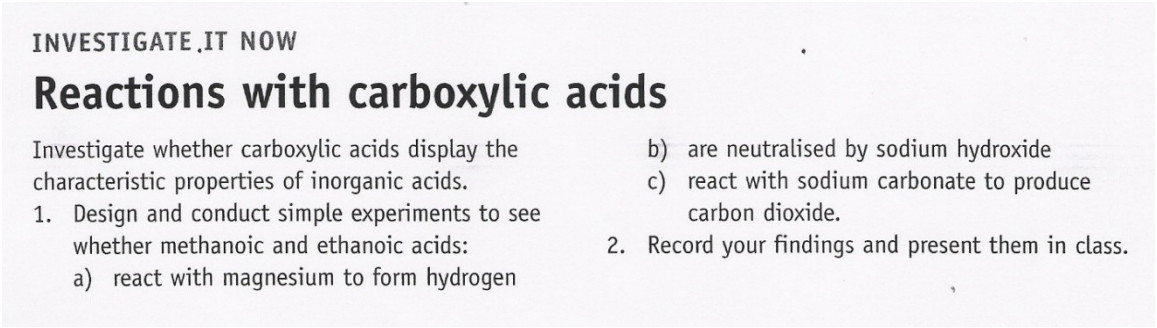


Figure 6.22 Elimination reactions of alcohols

- Structural formulae were used to show learners where the functional group is in the molecule and how this influences which type of reaction can occur.
- The 'Science in our world' activity about ethene in plants life cycle relates the material to everyday life by asking the learners questions about chemists

copying reactions that occur in nature and a practical activity that learners can do by using the ethene produced by bananas as a ripening agent.

- In chapter exercises 'Practise it now' designed to help the learners understand aliphatic reactions and compounds.
- 'Investigate it now' a recipe type practical activity on oxidizing ethanol with potassium permanganate or potassium dichromate.
- 'Investigate it now' (Figure 6.23) a practical activity in which the learners are expected to design and conduct a simple experiment which investigates the reactions of carboxylic acids.



INVESTIGATE IT NOW

Reactions with carboxylic acids

Investigate whether carboxylic acids display the characteristic properties of inorganic acids.

1. Design and conduct simple experiments to see whether methanoic and ethanoic acids:
   a) react with magnesium to form hydrogen
   b) are neutralised by sodium hydroxide
   c) react with sodium carbonate to produce carbon dioxide.
2. Record your findings and present them in class.

Figure 6.23 Investigate it now activity

- 'Review it now' which is an end of section exercise which allows the learners to review what they have learnt in this section.

The data obtained from the CoRe was coded using the six categories from Bishop and Denley's (2007) "Spinning Top" model and was compared to the data extracted from the examination guidelines.

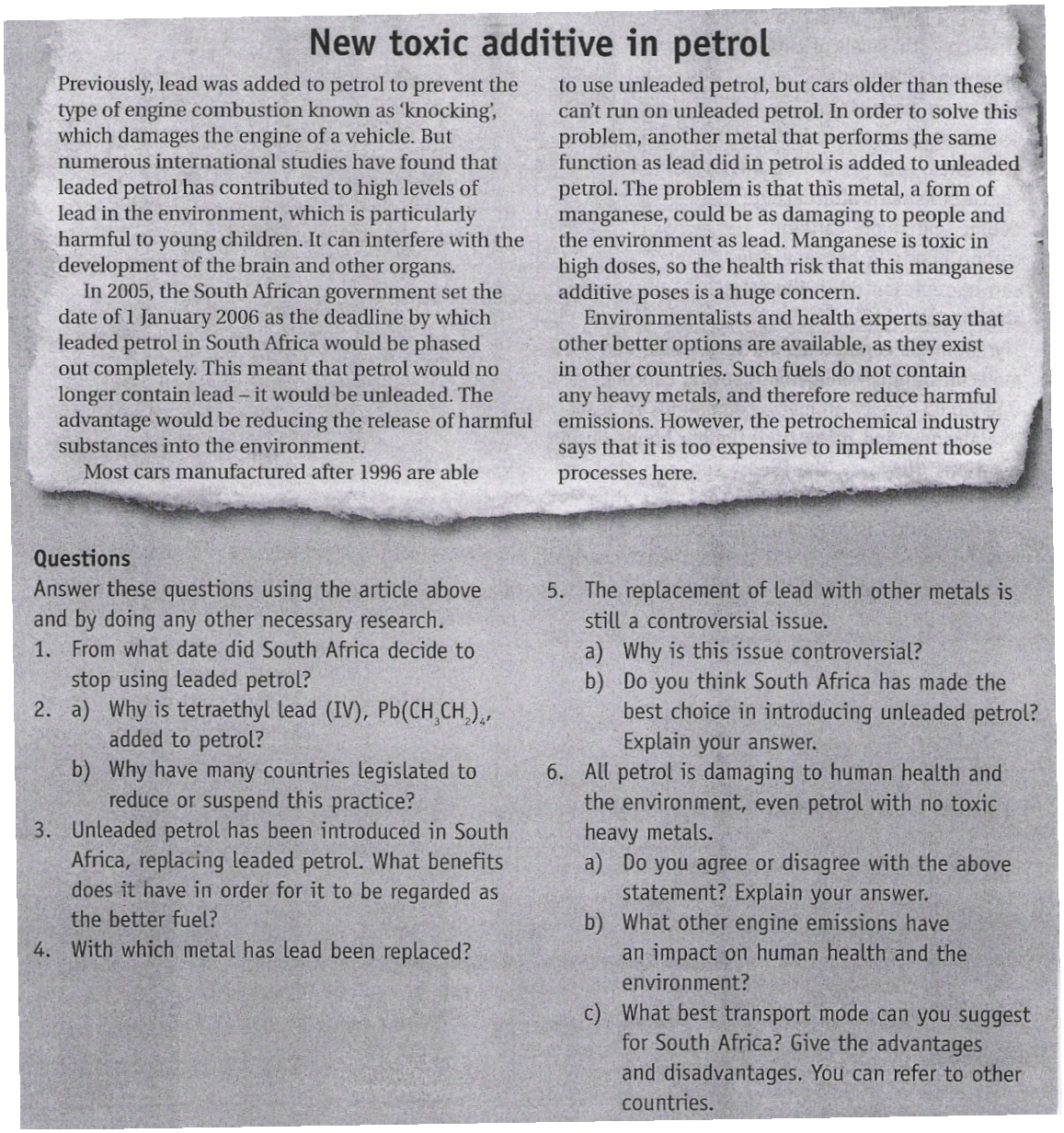
6.2.8 KNOWLEDGE OF THE CURRICULUM

The authors have demonstrated knowledge of the curriculum throughout the chapter. This knowledge did not always coincide with the examination guidelines. (Figure 6.24) However, as was mentioned in chapter 4 the authors used the original or intended curriculum documents to write this chapter. The authors had no prior knowledge of the changes that would be made and that would have influenced their thinking. Their knowledge of the curriculum is also reflected in the Teacher's Guide. Learning Outcomes and assessment standards are clearly indicated for each unit

and activities provided have included all three learning outcomes. An example of this is the activity 'Science in our world' (Figure 6.25) on leaded or unleaded petrol which includes questions on all three learning outcomes. The article gives the learners information about recent issues and gives the learners opportunities to consider issues that impact on the environment.

MAIN TOPICS OF DOE EXAMINATION GUIDELINES 2009	PHYSICAL SCIENCES EXPLAINED INFORMATION MISSING FROM CONTENT
Organic molecular structures- functional groups, saturated and unsaturated structures, isomers, systematic naming and formulae	Naming cyclo alkanes with alkyl substituents; Naming alkenes with alkyl substituents ;Conjugated, isolated and cumulated dienes; Branched dienes, alkyl substituents Alkynes, alkyl substituents; Branched haloalkanes, alkyl substituents Cyclic haloalkanes, alkyl substituents; Primary, secondary and tertiary alcohols, branched alcohols Branched carboxylic acids; Primary, secondary and tertiary amines, N or N,N; Amides, acyl group, N or N,N Branched aldehydes; Branched ketones
Structure and physical property relationships	Vapour pressure; Effect of branching on physical properties
Substitution, addition and elimination reactions	Hydro-halogenation, reaction conditions Rules for addition Cracking, thermal and catalytic Inter-conversions between alcohols and haloalkanes Primary and secondary bromoalkanes, reaction conditions Reaction of bases with haloalkanes

Figure 6.24 Missing content



New toxic additive in petrol

Previously, lead was added to petrol to prevent the type of engine combustion known as 'knocking', which damages the engine of a vehicle. But numerous international studies have found that leaded petrol has contributed to high levels of lead in the environment, which is particularly harmful to young children. It can interfere with the development of the brain and other organs.

In 2005, the South African government set the date of 1 January 2006 as the deadline by which leaded petrol in South Africa would be phased out completely. This meant that petrol would no longer contain lead – it would be unleaded. The advantage would be reducing the release of harmful substances into the environment.

Most cars manufactured after 1996 are able to use unleaded petrol, but cars older than these can't run on unleaded petrol. In order to solve this problem, another metal that performs the same function as lead did in petrol is added to unleaded petrol. The problem is that this metal, a form of manganese, could be as damaging to people and the environment as lead. Manganese is toxic in high doses, so the health risk that this manganese additive poses is a huge concern.

Environmentalists and health experts say that other better options are available, as they exist in other countries. Such fuels do not contain any heavy metals, and therefore reduce harmful emissions. However, the petrochemical industry says that it is too expensive to implement those processes here.

Questions

Answer these questions using the article above and by doing any other necessary research.

1. From what date did South Africa decide to stop using leaded petrol?
2. a) Why is tetraethyl lead (IV), $Pb(CH_3CH_2)_4$, added to petrol?
   b) Why have many countries legislated to reduce or suspend this practice?
3. Unleaded petrol has been introduced in South Africa, replacing leaded petrol. What benefits does it have in order for it to be regarded as the better fuel?
4. With which metal has lead been replaced?
5. The replacement of lead with other metals is still a controversial issue.
   a) Why is this issue controversial?
   b) Do you think South Africa has made the best choice in introducing unleaded petrol? Explain your answer.
6. All petrol is damaging to human health and the environment, even petrol with no toxic heavy metals.
   a) Do you agree or disagree with the above statement? Explain your answer.
   b) What other engine emissions have an impact on human health and the environment?
   c) What best transport mode can you suggest for South Africa? Give the advantages and disadvantages. You can refer to other countries.

Figure 6.25 Science in our world.

6.2.9 KNOWLEDGE OF THE CONTENT.

The authors need to demonstrate a flexible and comprehensive understanding of the subject matter they are presenting to the learners. There are numerous examples of this throughout the chapter. The authors have tried to present the content in ways that are easily understood and readily available to the learners. The new content has been presented in a numbered or bulleted format in small sections called 'Get the facts which sometimes also contain tables of information. An example of this is shown below in Figure 6.26: This table makes it easy for the learners to access

information on boiling and melting points and the phase of each of the four smallest alkynes. The bullets alongside give the learners some important facts about alkynes linking the table to the content.

GET THE FACTS

Alkynes

- The alkynes contain a triple bond, which makes them highly reactive compared to the alkanes.
- Alkynes, like alkanes and alkenes, exhibit similar physical properties – an increase in boiling and melting points as molecular size increases, densities lower than that of water, and being soluble in non-polar solvents.
- The table alongside shows some of these properties.

Name	Molecular structure	Melting point (°C)	Boiling point (°C)	Phase
Ethyne	C_2H_2	-82	-75	Gas
Propyne	C_3H_4	-101,5	-23	Gas
Butyne	C_4H_6	-122	9	Gas
Pentyne	C_5H_8	-98	40	Liquid
Hexyne	C_6H_{10}	-124	72	Liquid

Figure 6.26 Get the facts[6]

6.2.10 KNOWLEDGE OF VALUES, ENDS AND PURPOSES

This knowledge cannot be separated from the evaluation and assessment procedures. It also encompasses human values such as curiosity, creativity and questioning. There is evidence in this section that the authors are aware of this. Each unit starts with what questions are important for the learners to answer and which skills they are expected to practice (Figure 6.27).

You will answer these questions:

1. What properties do aliphatic compounds have?
2. How useful are organic compounds in our society?

You will practise these skills:

- applying knowledge
- comparing reactions and kind of products produced
- comparing properties of compounds and drawing conclusions.

[6] Bullet 1 in Figure 6.26 should refer to alkyne molecules.

Figure 6.27 Questions and skills for learners.

There is also a summative activity called “Review it now” at the end of the section for learners to practise what they learned as well as formative activities such as ‘Think it through’ and ‘Practise it now’ and ‘Investigate it now’.

6.2.11 KNOWLEDGE OF THE CONTEXT

Evidence is found in the chapter of the context of the organic chemistry as well as a few examples of the learners’ context. The learners’ context can be found in the way the new content is presented in a manner that makes the learners studying easier (Figure 6.26). An example of the context of the organic chemistry content is to found in (Figure 6.18).

As noted earlier in this chapter in the section on Big Idea 3, in the cartoon (Figure 6.15) the authors demonstrate their knowledge of the context in the way they engage the learners’ attention. Black learners and girls have not often been associated with the learning of science in the past. This is very important especially in the South African context.

6.2.12 KNOWLEDGE OF LEARNERS AND LEARNING

The Teacher’s Guide shows evidence of knowledge of learners and learning. In each unit teachers are informed how to teach the section and what to use while teaching e.g. the use of models to illustrate the formation of bonds as well as difference between straight chains and branched structures. The guide also encourages the teachers to discuss issues with the learners such as the difference between organic and inorganic etc. The authors are aware that mind maps (Figure 6.12) are important tools for conveying information for both learning and understanding. They recognise that learners will have to recognise patterns in classifying and naming organic compounds. The importance of inter-molecular forces is also noted by the authors in the revision of this grade 11 work (Figure 6.19) as learners find this abstract concept hard to understand and to relate to boiling and melting point, length of chain, mass, viscosity and functional groups.

6.2.13 GENERAL PEDAGOGICAL KNOWLEDGE

The general layout which refers to the manner in which the activities, content, tables etc have been included in the chapter demonstrates the general pedagogical knowledge of the authors. The book does not contain an index but does have a glossary for easy reference to meanings of words and definitions. In the 'Review it now' end of chapter exercise for the learners a list of important words is given telling the learners to make sure that they understand the meanings of the words and that they can be found in the glossary at the back of the book. The authors have also included revision of prior knowledge from previous grades showing that they are aware of difficulties that the learners may have as well as knowing that learners may not have access to the textbooks from previous grades.

6.3 AN OVERVIEW OF THE CHAPTER

The book is larger in size than the other two books described. The resource pack consists of a learners' book and a Teacher's Guide. Each module is divided into units each of which covers a specific topic. Questions are posed at the start of the unit that learners should be able to answer when the unit has been completed. The skills they should acquire are also described. A glossary is found at the end of the book and covers words which have been printed in bold typeface within the unit. The authors have not included the learning outcomes and assessment standards in the learners' book.

Activities called "Review it now ' draw the learners attention to terms they should know and important facts.

The reading level of the chapter is appropriate for grade 12 and appears to be appropriate for second language learners. The format of the book is visually appealing and the information has been presented by the authors in many different ways. Some of the pictures are fairly simplistic and although these pictures may appeal to the learners the use of scale is questionable.

The Teacher's Guide has detailed support for teachers and includes assessment rubrics for every activity. It follows a similar format to the Learners' Book. The authors show awareness of the learners' prior learning and suggest the importance of this to the teachers in the Teacher's Guide.

Five Big Ideas were developed in the CoRe and these linked to the five units that the authors had identified. They clearly divided the topic into five units. These topics although linked to topics covered in previous grades and other topics within the unit were self contained and the authors dealt with them in a logical, easy to follow format.

All of the Bishop and Denley knowledge bases were demonstrated by the authors in this section. However their knowledge of the curriculum did not always coincide with the examination guidelines as is seen from the missing information.

They showed throughout the chapter a comprehensive and flexible understanding of the material they are presenting to the learners. The way in which the material is presented to the learners shows their understanding of the context of the material as well as their knowledge of learners and learning. They have also included revision of content from previous grades which shows their understanding of the importance of prior learning.

CHAPTER 7

7.1 INTRODUCTION

In this chapter I draw some conclusions and attempt to answer the research questions by examining the analysis of the three textbooks and the examination guidelines and as well as critically reflecting on the research project. Some recommendations for further research are also made.

7.2 CRITICAL REFLECTIONS ON THE STUDY

This study is a content analysis and was meant to provide a detailed analysis of the organic chemistry content in three textbooks. The focus of the research was on how the authors of the books mediated the content for both teachers and learners.

I embarked on this research project after having marked the Grade 12 chemistry examination at the end of 2009. In this process as well as in my own teaching experience I realised that many learners and teachers were challenged by organic chemistry as the examination questions were, in general, answered very poorly. This in turn led to me reflecting on shortfalls in my own teaching, as well as the way the material is mediated for teaching and learning, in the textbooks. The research project was partly a personal response to the changes in the curriculum which have been a challenge to most teachers but this project is also about the need for quality textbooks for both learners and educators in the context of South African Physical Sciences education. There seems to be very little literature available on Physical Sciences textbooks in the South African context especially in the context of the new curriculum.

In retrospect the project was enormously challenging as at the time there were at least 12 textbooks on the list approved by the DOE and others not on the list available in various formats such as workbooks/textbooks; study guides etc. After some deliberation and advice from my supervisor I decided to select three textbooks which were available to the learners in the school in which I teach and to focus on only these three. The selection of these books was also a challenge as it would not have been possible to examine all twelve in detail.

Having no experience other than using the books as a teacher I attempted to find out how the organic chemistry content is transformed into a teachable form and to determine what teaching approaches are used by the authors of the books. I also attempted to evaluate the alignment of this content with the examination guidelines as Physical Sciences is historically one of the grade 12 subjects with the lowest pass rate.

The research questions were developed to try and find out what the problems with the organic chemistry content are and how they can be addressed. I chose to use the Bishop & Denley Model (2007) as my theoretical framework to extract and examine the various categories of knowledge that make up PCK as shown in chapter 4. In this model PCK is at the centre while the other six knowledge categories are arranged around the outside and these merge to make up PCK. Because of the tacit nature of PCK it was very difficult to analyse and many of the examples of PCK from the textbooks such as tables and activities that the author used to mediate the content may reflect more than one of the knowledge categories that make up PCK. For example a summative activity will reflect the authors' knowledge of values, end and purposes as well general pedagogical knowledge, knowledge of the curriculum, knowledge of learners and learning and content knowledge. This fits in with Bishop and Denley's (2007) model of PCK where individual knowledge bases tend to merge and become blurred. Because the knowledge of the curriculum appeared to be the heart of this research, I focussed on this area particularly.

Since the examination guidelines were used as the curriculum document and as a checklist there are many instances of the shortfalls in the text book authors' knowledge of the curriculum. The examination guidelines are used by teachers to ensure that they cover the material that is to be tested in the examinations. These guidelines reflect the aspects of the curriculum that the examiner wishes to examine and not the intended curriculum. As I have stated before this is not the authors' fault as they used the intended curriculum to write the books and not the examination guidelines which came later.

Because the material examined was already in the public domain an ethics clearance was not required but an ethics protocol number was obtained.

The method used for this research was a content analysis. This content analysis was done by using a textbook analysis tool, a CoRe or content representation and the examination guidelines. The reliability of content analysis depends on whether the researcher can code and classify the data in the same way over a period of time (Opie, 2009). A peer in the school at which I teach was asked to code some of the data in the textbook analysis tool independently and to check that the CoRe that was developed reflected what was evident in the textbooks. The coding of the data done by a peer was similar to what I had done but only one of each of the textbooks was checked. On reflection it probably would have been better to check all of the instruments and possibly to have more than one peer do the checking.

I adapted the tools that were used from existing instruments. By researching various instruments I got some ideas about the aspects of the textbooks that I needed to look into. In some cases I left out various options to include ideas from another. I tried to keep the criteria separate as I thought it would help me sort the data. However, I also realised the enormity of the task that I had embarked on. The textbook analysis tool which I developed from various existing tools consists of a series of prompts about various aspects of the content of the chapter on organic chemistry. The same instrument was used for all three textbooks and therefore the same questions were asked of each textbook. The instrument consisted of both open ended and closed questions and I tried to make the questions as unambiguous as possible and keep the focus of the question as simple as possible. I also tried to make the questions unbiased. A peer at the school at which I teach used the tool to see how the responses match with mine. Her responses were similar to mine. A good tool should avoid confusion and give the researcher valid and reliable data (Fraenkel & Wallen, 1990; Neuman, 1994; Opie, 2009).

A CoRe or content representation was used to provide an overview of how the authors approached teaching the topic and this includes what content is being taught, how it is being taught and why it is being taught. The authors had to make decisions about what should be excluded or included and the potential difficulties around teaching the topic. This process was extremely time consuming and complex as it is very difficult to know why and how something was done only from the text. I worked on my own and on reflection it may have been better to work with someone

else so that ideas could have been discussed. The CoRe or content representation is meant to be a reflection of the person who put it together. For this research I put the CoRe together but attempted to make it a reflection of the authors' mediation of the content. It is not meant to have a fixed amount of information or detail but should provide a solid base or overview of the topic. It was a difficult task and I am not sure that I succeeded entirely but I was able to identify aspects of the authors' PCK in all three textbooks.

The examination guidelines for 2009/2010/2011 were used as a checklist to see if any content was missing from the books. The guidelines provide a list of content on which the examiner can set questions. These guidelines are used by teachers as the curriculum document as they give the teacher an indication of what might be asked in the examination each year. I went through each book in turn and tried to find what was missing in each book. This also took an enormous amount of time.

In this study a substantial amount of data were collected some of which is beyond the scope of this research. The challenge was deciding which of the data should be used and which should be left out. As the authors of the books were not interviewed the CoRe was only developed from my perspective. In the end I used data collected from the textbook tool which gave a general overview of each book; the data collected from the representation of the content [CoRe] and data collected from the examination guidelines to answer the research questions.

This first research question alone could have been the basis of the research project as it could easily have been sub-divided into many smaller issues. I used a content representation or CoRe to try to capture the authors' pedagogical content knowledge which is found in many different forms in the textbooks such as the text itself, visual materials such as graphs, tables, illustrations, signposts, awareness of prior knowledge, misconceptions as well as questions and examples etc. It may have been better to try to focus on a few of these forms rather than all of them. It would have also been better to work on this project in a team rather than on my own as it would have been very useful to bounce ideas off colleagues. Evidence was found in all three textbooks of the authors' PCK.

The research questions are now addressed one by one.

7.3 RESEARCH QUESTION 1

How is the organic chemistry content mediated in the approved textbooks?

7.3.1 COMPARISON OF THE BIG IDEAS AND PCK

In Table 7.1 the Big Ideas from all three text books are shown. It is very interesting to note that these ideas are very similar in all three books. Since all the authors would all have been working from the same intended curriculum document they all had very similar ideas as to what was important. This highlights the fact that all the authors commonly viewed the same or similar concepts as important for the learners to learn in order to understand the topic.

In the third textbook Physical Sciences Explained, the authors clearly separated the content into five sections which I used as their Big Ideas. They separated the need for classification from naming and representation according to IUPAC rules. However, in spite of this their Big Ideas were also very similar to the other authors' ideas.

Table 7.1 Comparison of Big Ideas

STUDY AND MASTER PHYSICAL SCIENCES	FOCUS ON PHYSICAL SCIENCES	PHYSICAL SCIENCES EXPLAINED
Organic compounds are made from carbon chains with other elements to make different compounds with special arrangements called functional groups	Carbon is unique and has the ability to form rings and chains	Carbon has special properties which make it unique
		Organic compounds are classified according to their bonds or structures.
Organic compounds are named according to very specific rules set out by IUPAC.	There are multiple ways of representing organic substances which are named using a standard system [IUPAC] of naming	Organic compounds are named and represented according to IUPAC rules.
The properties and uses of organic compounds are linked to their functional groups	Organic compounds show distinctive physical and chemical properties.	Organic compounds have characteristic chemical and physical properties.
The reactions that organic compounds undergo are linked to their structures and their functional groups	Organic reactions depend on the distinctive physical and chemical properties of organic molecules to determine the types of reactions they undergo.	Reactions that organic substances undergo are determined by the characteristic chemical and physical properties.

The authors of all three books chose what was to be taught and learned and how it was going to happen by selecting the various tasks and activities throughout the section on organic chemistry. They decided on the sequencing of the teaching and learning. The exercises and assessments are ways of evaluating the learners' progress.

In all three books the authors showed a flexible and comprehensive understanding of the subject matter that they were presenting. They all used fairly similar ways of presenting the content to the learners by using tables, pictures, diagrams, structural formulae etc. This is a very important aspect of subject matter knowledge. Shulman (1986) described subject matter knowledge as more than the knowledge of information or concepts. This knowledge requires the authors to understand the facts and how they need to be organised as it is essential to teaching and learning. The authors' role is to help the learner learn through using activities to build their knowledge and understanding and this requires more than just the delivery of information. It is important for the text to represent the ideas and concepts accurately and comprehensively.

The authors also demonstrated knowledge of the curriculum by including learning outcomes and assessment standards in the teaching guidelines and by indicating key concepts at the start of the sections etc. The curriculum is the body of knowledge that the authors want to share with the learners and it also attempts to achieve certain goals. One of these goals is obviously the examination that the learners would have to write at the end of the process. The curriculum is more than just the body of knowledge or content as it includes the way in which the material is transformed. All three of the books, in my opinion, did not present the curriculum in an adequate way for the learners to study from for their examinations as a substantial amount of material was missing from the books.

Knowledge of the context of the organic chemistry was evident in all three books. However, in Study and Master Physical Sciences the lack of activities including Learning Outcome three was evident. The other two books both included activities and it was evident that the authors tried to engage the learners in their choice of activities. In Physical Sciences Explained the authors showed that they were aware that the material was meant for the South African context by including pictures of

black learners and a female learner. This was the only example of women and minorities being supported in the three books.

Knowledge of values, ends and purposes cannot be separated from evaluation and assessment procedures. In all three books the authors demonstrated that they were aware of this by including assessment tasks and rubrics etc in the Teacher's Guides. Subject matter knowledge has to include opportunities for the learners to re-examine the content for themselves. The authors of Focus on Physical Sciences and Physical Sciences Explained use bold text to highlight important words and terms to the learners and also included these in a glossary at the end of the book.

All of the books showed evidence of the authors' knowledge of learners and learning in the way the material was presented to the learners for example in their use of text boxes, tables etc. The authors also included useful information in the Teacher's Guides relating to the subject, learning outcomes etc. Focus on Physical Sciences included an examination Practice Booklet which gave the learners useful tips for examination preparation and the writing of examinations. It also included notes on how to approach questions as well as including model answers. The other two books did not include any actual examination questions or model answers for the learners.

Knowledge of learners and learning needs to incorporate an understanding of misconceptions and prior learning and what teaching strategies are going to be used to address these issues. The authors of Physical Science Explained demonstrated this in the way in which they dealt with the revision of inter-molecular forces.

The manner in which the material was laid out in all three of the books showed evidence of the authors' general pedagogical knowledge. This refers to the order and way in which the information, activities, notes have been included. Focus on Physical Sciences and Physical Sciences Explained presented the material in a way that was more likely to engage the learners' attention as the text was less dense.

7.3.2 COMPARISON OF GENERAL FEATURES OF THE TEXTBOOKS

As can be seen from Table 7.2 in the comparison of some of the general features of the textbooks the books are very similar in certain aspects such as the reading level. However, the lower value obtained for Physical Sciences Explained may indicate

that this text is more suitable for second language learners. It is also set out in a manner which is user friendly and therefore suitable for the learners. The text in Study and Master Physical Sciences appears dense and does not appear to be as user friendly. The effort a learner must put into understanding the text while studying on their own is critical to the success of the textbook. Learners need to make connections between what they already know and the information they are reading. In my opinion the authors of Focus on Physical Sciences and Physical Sciences Explained tried by including signposts to prior knowledge and revision content, to help the learners make these connections.

Both Focus on Physical Sciences and Physical Sciences Explained use bold typeface to indicate important terms, which are then defined in the glossary at the end of the book. Study and Master Physical Sciences does not contain a glossary. Focus on Physical Sciences also contains an index which helps learners find content on various topics easily. Focus on Physical Sciences and Physical Sciences Explained both have a variety of different types of activities which appear to cater for the different needs of the learners. All of the textbooks could have developed the topics covered more thoroughly.

The format and illustrations in the textbooks need to be attractive to the reader so that they are not put off before they have interacted with the text. The authors of Physical Sciences explained have made an effort to keep pictures simple and easy to understand and have also used a cartoon to engage the learners attention which includes female and black learners which shows their knowledge of the South African context.

To answer research question 1 I believe that all three textbooks have developed texts with useful elements and the authors of all three books have shown PCK in all six of the knowledge categories. Teachers who use these texts will be able to find useful information and activities in all three. However in my opinion Focus on Physical Sciences has information that is possibly the most valuable to the learners as it includes the other resources for the learner to use i.e. the practicals book and the exam practice book.

Table 7.2 Comparison of general features in the textbooks

COMPARISON OF SOME OF THE GENERAL FEATURES OF TEXTBOOKS			
CRITERION	**STUDY AND MASTER PHYSICAL SCIENCES**	**FOCUS ON PHYSICAL SCIENCES**	**PHYSICAL SCIENCES EXPLAINED**
Textbook provides a separate teachers' edition and other resources	Resource package consists of a Learners' Book and a Teacher's Guide	Resource package consists of a Learners' Book and a Teacher's Guide, Examination Practice book, Practicals book and CD ROM	Resource package consists of a Learners' Book and a Teacher's Guide
Table of contents	Present at the beginning of book	Present at the beginning of book	Present at the beginning of book
Glossary	No glossary	At end of book	At end of book
Index	No index	At end of book	No index
Information is accurate and current [Textbook aligns with the examination guidelines]	Not all the information in the chapter links with the examination guidelines. Specific examples are listed in the table on examination guidelines.	Not all the information in the chapter links with the examination guidelines. Specific examples are listed in the table on examination guidelines.	Not all the information in the chapter links with the examination guidelines. Specific examples are listed in the table on examination guidelines.
Reading level is appropriate for age/grade	Grade level is between 10.2 and 12.4.	Grade level is 11.1 and 12	Grade level is between 7.4 and 12.8
Text and illustrations are not stereotypical and/or prejudicial	No examples of stereotypical and prejudicial text of illustrations found. However no pictures of girls or black learners present.	No examples of stereotypical and prejudicial text of illustrations found.	No examples of stereotypical and prejudicial text of illustrations found. Cartoon illustrating black learners and a female learners discussing classification of organic compounds
No of pages in book	416	282	324
No. of pages on organic chemistry content [excluding organic macromolecules which is not in examination guidelines]	28	18	22

The textbooks need to appeal to the learners as well as the teachers. In my opinion Focus on Physical Sciences and Physical sciences Explained will engage the learners more than Study and Master Physical Sciences.

7.4 RESEARCH QUESTION 2

Is the organic chemistry content of the books aligned with the examination guidelines?

a. If not what changes need to be made?

The examination guidelines were used as the curriculum document in this research although this was not strictly fair to the authors of the book as this was not the

intended curriculum from which they would have written the textbooks. However the learners have to use the textbooks to study for the examinations and the teachers use the examination guidelines as a curriculum tools so I therefore used the document as a checklist to ascertain what information was missing from the books.

This was documented in the previous chapters as knowledge of the curriculum. There were instances in all three textbooks of 'missing' knowledge of the curriculum. This 'missing' knowledge is shown in the table 7.3.

As can be seen from Table 7.3 in each of the three books there is a lot of content missing from the books. In some cases the lack of examples on naming would make it very difficult for learners to tackle naming some of the more complex structures on their own. While it is obviously up to the teacher to fill in some of the gaps none of the three books tackled naming comprehensively. The examples in the books were mainly simplistic when compared to the level required by the guidelines. It is however, true that most of these more complex structures required in the guidelines have not been examined except for naming amines with the N or N,N prefixes. I have included a complete copy of the examination guidelines appendix 3.

The guidelines are also very specific on the types of reactions and the reaction conditions that the learners are required to know as well as the rules for addition and elimination reactions. The guidelines do not specifically name the rules by their names i.e. Zaitsev's and Markonikov's rules but they are specified quite clearly. These lead to minor and major products in addition reaction and the formation of double bonds in specific sites in elimination reactions. Again none of the textbooks covered this area adequately. In fact if teachers were not clear about how the rules worked the textbooks would have been little or no help to them at all. In my opinion if these rules are going to be examined it is very important that they are included in the text. However, I do not think that the mechanism of reaction was in the intended curriculum.

In the section on structural and physical property relationships content on vapour pressure and the effects of branching on physical properties such as boiling and melting points was also inadequately covered.

Table 7. 3 Missing Information from Examination Guidelines

COMPARISON OF TEXTBOOKS WITH EXAMINATION GUIDELINES			
MAIN TOPICS OF DOE EXAMINATION GUIDELINES 2009	**STUDY AND MASTER PHYSICAL SCIENCES INFORMATION MISSING FROM CONTENT**	**FOCUS ON PHYSICAL SCIENCES INFORMATION MISSING FROM CONTENT**	**PHYSICAL SCIENCES EXPLAINED INFORMATION MISSING FROM CONTENT**
Organic molecular structures-functional groups, saturated and unsaturated structures, isomers, systematic naming and formulae	Naming of cyclo-alkanes with or without alkyl substituent groups. Naming of alkenes with alkyl substituent groups. Isolated and cumulated dienes Naming of alkynes with alkyl substituent groups. Naming of halo-alkanes, cyclic haloalkanes Primary, secondary and tertiary alcohols, alkyl substituents Branched carboxylic acids. Primary, secondary and tertiary amines N and N,N in naming of amines. Naming of aldehydes with substituent groups Naming of ketones with substituent groups Arenes- alkyl substituents	The term substituent group not used. Examples of alkanes only include 1 branch. Naming of cyclo-alkanes with or without alkyl substituent groups. Naming of alkenes with alkyl substituent groups. Isolated and cumulated dienes Naming of alkynes with alkyl substituent groups. Naming of halo-alkanes, cyclo haloalkanes Primary, secondary and tertiary alcohols, alkyl substituents Branched carboxylic acids. N and N,N in naming of amines. Acyl group Naming of aldehydes Naming of ketones	Naming cyclo alkanes with alkyl substituents Naming alkenes with alkyl substituents Conjugated, isolated and cumulated dienes Branched dienes, alkyl substituents Alkynes, alkyl substituents Branched haloalkanes, alkyl substituents Cyclic haloalkanes, alkyl substituents Primary, secondary and tertiary alcohols, branched alcohols Branched carboxylic acids Primary, secondary and tertiary amines, N or N,N Amides, acyl group, N or N,N Branched aldehydes Branched ketones
Structure and physical property relationships	Vapour pressure Viscosity	Viscosity [reference oily liquids]	Vapour pressure Effect of branching on physical properties
Substitution, addition and elimination reactions	Hydro-halogenation & reaction conditions H atom attaches to carbon atom with the greater number of H atoms; X atom attaches to the more substituted C atom. Hydration-reaction conditions, position of attachment of OH group Substitution reactions-primary, secondary and tertiary alcohols	Addition reactions of alkynes &reaction conditions; H atom attaches to carbon atom with the greater number of H atoms; X atom attaches to the more substituted C atom. Hydration-reaction conditions, position of attachment of OH group. Hydrogenation-reaction conditions i.e. non polar solvent. Elimination-Dehydro-halogenation; reaction condition, major and minor products. Dehydration reactions-reaction conditions, minor and major products. Substitution reactions-inter-conversion between alcohols and haloalkanes, primary and secondary bromoalkanes, reaction conditions. Reactions of bases with haloalkanes to produce alcohols, reaction conditions	Hydro-halogenation, reaction conditions Rules for addition Cracking, thermal and catalytic Interconversions between alcohols and haloalkanes Primary and secondary bromoalkanes, reaction conditions Reaction of bases with haloalkanes

The reaction conditions have been important in some examination questions in helping learners identify the types of reactions and again these were not all specified

for the learner. As a teacher I encourage my learners to use the examination guidelines while studying for examinations and if the textbooks these learners are using are missing important content it becomes very difficult for them to work things out for themselves.

7.5 CONCLUSIONS

The process of introducing the new curriculum was flawed from the start. The authors and publishers produced books from the intended curriculum and then the examination guidelines were amended very soon after the first NSC examinations. Some of the publishers have updated and reprinted new editions updating the content but schools which had chosen textbooks cannot afford to purchase new ones for their learners. In my school for example learners pay a once off levy which entitles them to borrow books for each year after which they are returned to the school for the next set of learners. These books are a precious resource as most of the parents would be unable to purchase a full set of textbooks for their children. With the introduction of CAPS in 2012 for grade 10 yet more books would have to be purchased.

The chemistry examiners have included questions in the examinations on content which is not in all the textbooks. The learners in many schools are already disadvantaged by having teachers who are not qualified and unable to supplement the books adequately. Some of the workbooks not examined in this study but which appear to have included some of this content were not placed on the approved textbook list.

Although all of the authors in the three textbooks that were examined in this study showed evidence of the content being mediated for teaching and learning none of them were a complete package that could be used by learners while studying on their own for the examinations. The content would have had to have been substantially further mediated by the teachers to make sure that their learners were adequately prepared for the examinations.

7.6 RECOMMENDATIONS

With the advent of the CAPS [Curriculum Assessment Policy Statements] being introduced into grade 10 in 2012 it would be interesting to see and track what changes will be made to the textbooks. However, the list of approved science textbooks for the introduction of CAPS in grade 10 in 2012 has been reduced to just four textbooks. Many schools will not be able to afford to replace the books they have and will have to make 'do' by providing learners with notes for the missing sections. It would be very interesting to know why these four books have been chosen and what criteria were used to make this decision. Interestingly so far I have only received one sample copy and that is from a publisher who is not on the approved list.

While doing the research it appeared to me as if the level of some of the questions in the textbooks was not in line with the questions in the examination and I believe that this could also be a starting point for further research. It also appears as if there are not sufficient practice questions for the learners in the textbooks and the answers are only supplied in the teachers' guide. When learners are studying on their own I believe there is merit in having the answers at the very least and a full memorandum at best.

The level of analysing the PCK could be much more detailed than this study and the South African books could possibly be compared to books from other countries in an attempt to see what could be improved.

As can be seen from the information that is missing from the text there is a lack of detail on the mechanism of reaction in this section. I do, however, believe that the mechanism of reaction was never intended to be part of the grade 12 examination. I quote from the moderators report on the 2010 chemistry examination-"learners are starting to recognize the use of Markovnikov's and Zaitsev's rules" (Moderators Report: Part 3: Analysis of Learners' Responses, 2010). Although the examination guidelines to not specifically refer to these rules the learners would have to know and understand them to be able to answer questions on major and minor products. There have been some workshops for teachers but not all teachers were able to attend. However questions on these aspects of reaction mechanism were asked in 2008,

2009 and 2010. It must also be noted that in 2010 teachers were asked to give learners a glossary of terms by their subject advisors and these included definitions of the above rules.

This appears to mean that the Department of Education was aware of the inadequacy of the resource materials available to teachers and learners.

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