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Quality Council for General and Further Education and Training

International Benchmarking of the South African National Senior Certificate (NSC)
Subject Findings
Appendix: Physical Sciences

20th Anniversary

Two Decades of Education Guardianship
2002 - 2022

International Benchmarking of the South African National Senior Certificate (NSC) Subject Findings Appendix: Physical Sciences

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Introduction

Overview of NSC Physical Sciences

The NSC Physical Sciences curriculum combines the investigation of physical and chemical phenomena within one subject. This is an optional subject within the NSC science subjects. As well as addressing key ideas and traditional areas of inquiry in physics and chemistry, the curriculum also pays specific attention to Indigenous Knowledge Systems (IKS) and the means by which people apply the scientific method and understand the physical environment.

Subject documentation articulates how:

> "NSC Physical Sciences prepares learners for future learning, specialist learning, employment, citizenship, holistic development, socio-economic development, and environmental management. Learners choosing Physical Sciences as a subject in Grades 10-12, including those with barriers to learning, can have improved access to: academic courses in Higher Education; professional career paths related to applied science courses and vocational career paths. Physical Sciences plays an increasingly important role in the lives of all South Africans owing to their influence on scientific and technological development, which are necessary for the country's economic growth and the social wellbeing of its people."

NSC students selecting Physical Sciences must also take NSC Mathematics (rather than NSC Mathematical Literacy).

Structure of Appendix

This subject comparison appendix addresses the relationship between NSC Physical Sciences and subjects which fulfil similar roles in five alternative programmes. This appendix is structured to first demonstrate points of comparability and contrasts between the subjects (under the subheading Comparison) and then to synthesise this into Key Findings with a particular focus on skill development. This analysis examines all comparison subjects against NSC Physical Sciences simultaneously, to enable stakeholders to see the range of similarities and differences across the international contexts in a single place. The analysis is based on the review of the NSC Physical Sciences and assessment documentation for grades 10 to 12, and more specifically on the 2011 Curriculum and Assessment Policy Statement for Physical Science and the 2017 Examination Guidelines and the 2020 Marking Guidelines for Physical Science.

Comparison

Subjects in Context

The IB DP curriculum is made up of six subject groups and the DP core. Students have to choose a minimum of 1 option from the sciences block, so could feasibly choose any combination of two sciences, i.e. Chemistry and Physics as reviewed here. IB DP Chemistry and Physics are both offered at either standard level (SL) or higher level (HL). Although the IB separates Physics and Chemistry as distinct curricula, they have some shared features (along with IB DP Biology) in terms of, for example, assessment objectives.

The Physics and Chemistry International AS/A Levels offered by Cambridge Assessment International Education are optional individual subjects for students likely to be seeking entry into universities globally, likely to major in subjects related to these subjects. Cambridge International also offers a AICE Diploma which can be made up of a combination of subjects at International A Level or the subjects can be treated as stand-alone. The AICE certification is made up of a combination of sciences, humanities, arts and a compulsory Global Perspectives subject, giving a broader curricular focus. The Physics and Chemistry curricula in these International AS/A levels are distinct awards, though with some structural similarities.

The entry point to the KCSE Physics and Chemistry subjects is based on students having completed and reached a particular passing standard by the end of the general primary curriculum. The subject material builds upon the basics covered at primary level and some of the topic themes and theories will be introduced for the first time.

In Zimbabwe, Physics and Chemistry are offered as standalone subjects in Forms 5-6. Structurally, these two curricula have some similarities with the Cambridge International AS/A Levels, though there are also a number of differences.

The NSW HSC also offers Physics and Chemistry as distinct subjects at stage 6. These curricula can form part of the wider higher-school certification programme (HSC), though each subject also stands alone as a subject in its own right. The subject material has specialist subject areas, practical requirements and structural elements similar to the NSC Physical Sciences.

Entry Requirements, Duration, Mode of Study, Progression Routes

The table below summarises any formal entry requirements for each subject, expected prior learning, the duration of study within the programme, the mode of study, and any notable facts about progression routes which study of each subject enables either nationally or internationally.

Table 1: Comparison of subject-specific entry requirements, expected prior learning, duration of study and recommended progression routes

	Subject-Specific Entry Requirements	Expected Prior Learning	Duration of Study	Recommended Progression Routes
NSC Physical Sciences[1]	For Grade 10: • An official Grade 9 school report which indicates that a learner has met the requirements for promotion to Grade 10 or; • a General Education and Training Certificate (GETC) for Adult Basic Education and Training (ABET); or • a NQF Level 1 Certificate which requires two languages; or • a recognised equivalent qualification obtained at NQF Level 1 which requires two official languages. • an official document of approval from the relevant Head of Education confirming that a learner who has received home education prior to Grade 10 has reached the required level in Grade 9. • For Grades 11 and 12: • For Entrance into Grades 11 and 12, an appropriate statement of achievement at the appropriate levels is issued by an approved or recognised assessment body.	No assumed learning required stated in subject documentation.	3-year programme (Grades 10-12) which require 4 guided learning hours per week	Subject documentation states that the subject provides "improved access to: academic courses in Higher Education; professional career paths related to applied science courses and vocational career paths".
IB DP Physics HL/SL[2]	Schools will engage with students' educational backgrounds on an individual basis	Prior general level certification in each territory in science and maths	Standard level 150 teaching hours. Higher level 240 teaching hours.	Primarily focused on entry to tertiary education institutions globally.

[1] National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Physical Sciences.;* Department of Basic Education Republic of South Africa (2021), National Policy Pertaining to the Programme and Promotion Requirements of the National Curriculum Statement. Grades R-12, pp. 29-30.

[2] International Baccalaureate Diploma Programme (2016), *Physics Guide*.

	Subject-Specific Entry Requirements	Expected Prior Learning	Duration of Study	Recommended Progression Routes
IB DP Chemistry HL/SL[3]	Schools will engage with students' educational backgrounds on an individual basis	Prior general level certification in each territory in science and maths	Standard level 150 teaching hours. Higher level 240 teaching hours.	Primarily focused on entry to tertiary education institutions globally.
Cambridge International AS/A Level Physics[4]	Schools will engage with students' educational backgrounds on an individual basis.	Recommended completion of Cambridge O Level or Cambridge IGCSE® course, or the equivalent, in Physics or in Co-ordinated Science.	1 year or 180 learning hours for AS Level course 2 Years or 360 learning hours for full A Level course	A Level Physics provides a suitable foundation for the study of Physics or related courses in tertiary education for students intending to pursue careers or further study in • Physics • Engineering • or as part of a course of general education AS Level Physics standalone qualification may permit or assist progression directly to tertiary courses in Physics or some other subjects.

[3] International Baccalaureate Diploma Programme (2016), *Chemistry Guide*.

[4] Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Physics 9702*, p. 5.

	Subject-Specific Entry Requirements	Expected Prior Learning	Duration of Study	Recommended Progression Routes
Cambridge International AS/A Level Chemistry[5]	Schools will engage with students' educational backgrounds on an individual basis.	Recommended completion of either: • Cambridge O Level or Cambridge IGCSE® course • the equivalent, in Chemistry or in Co-ordinated Science.	1 year or 180 learning hours for AS Level course 2 Years or 360 learning hours for full A Level course	A Level Chemistry provides a suitable foundation for the study of chemistry or related courses in tertiary education for students intending to pursue careers or further study in • chemical sciences, • or as part of a course of general education. AS Level Chemistry standalone qualification may permit or assist progression directly to tertiary courses in Chemistry or some other subjects.
KCSE Physics[6]	School candidates must be holders of KCPE Certificate or its equivalent. Prospective candidates with foreign certificates must seek equation of the foreign certificates before being admitted into the Kenyan schools.	KCPE Science or equivalent	4 years	Students who scored an aggregate of C+ grade and above will be selected for the degree placement procedure, in both private and public universities, and their degree will be sponsored by the government.

[5] Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Chemistry 9701*, pp.5-6.

[6] The Kenya National Examinations Council (2014), *Kenya Certificate of Secondary Education (KCSE): Examinations Regulations and Syllabuses*.

	Subject-Specific Entry Requirements	Expected Prior Learning	Duration of Study	Recommended Progression Routes
KCSE Chemistry[7]	School candidates must be holders of KCPE Certificate or its equivalent. Prospective candidates with foreign certificates must seek equation of the foreign certificates before being admitted into the Kenyan schools.	KCPE Science or equivalent.	4 years.	Students who scored an aggregate of C+ grade and above will be selected for the degree placement procedure, in both private and public universities, and their degree will be sponsored by the government.
ZIMSEC Physics Forms 5-6[8]	No subject-specific entry requirements are mentioned in the qualification documents.	Subject documentation articulates the expectations that: • "The learner has successfully completed Form 3 and 4 Physics Syllabus or any other equivalent syllabus. • The learner has successfully completed Form 3 and 4 Mathematics syllabus. • Learners are conversant and have access to ICT."	2 Years A minimum of 12 periods of 35 minutes each in a week should be allocated as double periods for adequate coverage of the syllabus.	Not stated.

7 The Kenya National Examinations Council (2014), *Kenya Certificate of Secondary Education (KCSE): Examinations Regulations and Syllabuses*.

8 Zimbabwe Ministry of Primary and Secondary Education (2015), *Physics Syllabus Forms* 5-6.

	Subject-Specific Entry Requirements	Expected Prior Learning	Duration of Study	Recommended Progression Routes
ZIMSEC Chemistry Forms 5-6[9]	No subject-specific entry requirements are mentioned in the qualification documents.	Subject documentation articulates the expectation that students: • "have passed 'O' level Chemistry • are familiar with ICT Tools and Braille/Jaws software • have passed 'O' level Mathematics • are familiar with laboratory apparatus • are aware of laboratory safety precautions".	2 years. 8 theory 40 minutes periods and a block of 4 x 40 practical periods per week is recommended.	Not stated.
NSW HSC Physics[10]	Not stated.	Science in Years 7-10.	240 hours over 2 years. Additional 15 hours depth studies per year	Awarding body documentation claims that "Students progress into community, other education and learning and workplace pathways"
NSW HSC Chemistry[11]	Not sated.	Science in Years 7-10.	240 hours over 2 years. Additional 15 hours depth studies per year	Awarding body documentation claims that "Students progress into community, other education and learning and workplace pathways"

9 Zimbabwe Ministry of Primary and Secondary Education (2015), *Chemistry Syllabus Forms* 5-6.

10 New South Wales Education Standards Authority (2017), New South Wales Syllabus for the Australian Curriculum: Physics Stage 6 Syllabus.

11 New South Wales Education Standards Authority (2017), New South Wales Syllabus for the Australian Curriculum: Chemistry Stage 6 Syllabus.

The NSC curriculum, like many of the other international comparator programmes, there is some prior knowledge required and a level of prior education or certification required. In terms of entry requirements to the South African NSC, a passing grade from previous years schooling needs to be achieved (pass in Grade 9), and to progress through the NSC programme a passing grade is required in each year.

The NSC Physical Sciences programme has similarities to NSW HSC, IB DP, Cambridge International, and ZIMSEC Chemistry and Physics as all of these programmes are primarily aimed at post general secondary level sciences / pre-university entry level qualifications. They share the following features:

- Primary post general secondary / pre-university qualifications.
- Students are likely to have chosen some aspect of their studies / sciences, or specifically Chemistry / Physics as separate subjects or to form part of their wider diploma.
- English is the main teaching language for the majority of science subjects in each territory.
- Students will have to have reached a certain standard of mathematical capability before starting these curricula. This could be through a previous mathematical qualification or "passing" a prior grade.
- Specific entry requirements vary slightly from country to country and education establishment to establishment.
- There is a requirement for general science knowledge and skills, perhaps a passing grade at general science and mathematics to access the material covered.
- All are typically full-time and classroom based.

The NSC curriculum is unique in its three-year approach to learning, plus its helicoidal structure meaning that the curriculum builds in difficulty year on year, but there are no other "lower" level qualifications after a year, like Cambridge International AS Level where credit at a lower level is awarded.

Subject Aims

The following table lists the stated aims of each subject according to each programme's documentation. Where curriculum documentation does not explicitly articulate aims with, for example, a subheading titled "Aims", Ecctis have selected passages or extracts which most closely resemble a brief overview of the subject's purpose. This is intended to enable comparison between the different curricula as effectively as possible. Where something not labelled "aims" has been used to stand-in for curriculum aims, this is explained in the descriptive analysis underneath the table.

Table 2: Comparison of subject aims

	Subject Aims
NSC Physical Science[12]	The purpose of Physical Sciences is to make learners aware of their environment and to equip learners with investigating skills relating to physical and chemical phenomena, for example, lightning and solubility. Examples of some of the skills that are relevant for the study of Physical Sciences are classifying, communicating, measuring, designing an investigation, drawing and evaluating conclusions, formulating models, hypothesizing, identifying and controlling variables, inferring, observing and comparing, interpreting, predicting, problem-solving and reflective skills. Physical Sciences promotes knowledge and skills in scientific inquiry and problem solving; the construction and application of scientific and technological knowledge; an understanding of the nature of science and its relationships to technology, society and the environment. Six main knowledge areas inform the subject Physical Sciences. These are: • Matter and Materials • Chemical Systems • Chemical Change • Mechanics • Waves, Sound and Light • Electricity and Magnetism
IB DP Physics[13]	Through studying physics, students should become aware of how scientists work and communicate with each other. While the scientific method may take on a wide variety of forms, it is the emphasis on a practical approach through experimental work that characterises these subjects. The aims enable students, through the overarching theme of the Nature of science, to: • appreciate scientific study and creativity within a global context through stimulating and challenging opportunities • acquire a body of knowledge, methods and techniques that characterize science and technology • apply and use a body of knowledge, methods and techniques that characterize science and technology • develop an ability to analyse, evaluate and synthesize scientific information • develop a critical awareness of the need for, and the value of, effective collaboration and communication during scientific activities • develop experimental and investigative scientific skills including the use of current technologies • develop and apply 21st century communication skills in the study of science • become critically aware, as global citizens, of the ethical implications of using science and technology • develop an appreciation of the possibilities and limitations of science and technology • develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge

[12] National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Physical Sciences*.

[13] International Baccalaureate Diploma Programme (2016), *Physics Guide*, p. 18.

	Subject Aims
IB DP Chemistry[14]	Through studying chemistry, students should become aware of how scientists work and communicate with each other. While the scientific method may take on a wide variety of forms, it is the emphasis on a practical approach through experimental work that characterizes these subjects. The aims enable students, through the overarching theme of the Nature of science, to: • appreciate scientific study and creativity within a global context through stimulating and challenging opportunities • acquire a body of knowledge, methods and techniques that characterize science and technology • apply and use a body of knowledge, methods and techniques that characterize science and technology • develop an ability to analyse, evaluate and synthesize scientific information • develop a critical awareness of the need for, and the value of, effective collaboration and communication during scientific activities • develop experimental and investigative scientific skills including the use of current technologies • develop and apply 21st century communication skills in the study of science • become critically aware, as global citizens, of the ethical implications of using science and technology • develop an appreciation of the possibilities and limitations of science and technology • develop an understanding of the relationships between scientific disciplines and their influence on other areas of knowledge

Cambridge International AS/A Level Physic[15]	The aims listed below are not in order of priority.
	The aims of a course based on this syllabus should be to:
	• provide, through well-designed studies of experimental and practical science, a worthwhile educational experience for all learners, whether or not they go on to study science beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge to:
	• become confident citizens in a technological world and be able to take or develop an informed interest in scientific matters
	  • recognise the usefulness, and limitations, of scientific method and appreciate its applicability in other disciplines and in everyday life
	  • be suitably prepared for studies beyond Cambridge International A Level in physics, in engineering or in physics-dependent vocational courses.
	• develop abilities and skills that:
	• are relevant to the study and practice of science
	  • are useful in everyday life
	  • encourage efficient and safe practice
	  • encourage effective communication.
	• develop attitudes relevant to science such as:
	• a concern for accuracy and precision
	  • objectivity
	  • integrity

[14] International Baccalaureate Diploma Programme (2016), *Chemistry Guide*, p.18.

[15] Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Physics 9702*, p.11.

	Subject Aims
	• a spirit of enquiry • initiative • inventiveness. • stimulate interest in, and care for, the environment in relation to the environmental impact of physics and its applications. • promote an awareness: • that the study and practice of physics are co-operative and cumulative activities, and are subject to social, economic, technological, ethical and cultural influences and limitations • that the applications of physics may be both beneficial and detrimental to the individual, the community and the environment • of the importance of the use of IT for communication, as an aid to experiments and as a tool for the interpretation of experimental and theoretical results. • stimulate learners and create a sustained interest in physics so that the study of the subject is enjoyable and satisfying
Cambridge International AS/A Level Chemistry[16]	The aims listed below are not in order of priority. The aims of a course based on this syllabus should be to: • provide, through well designed studies of experimental and practical chemistry, a worthwhile educational experience for all learners, whether or not they go on to study science beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge to: • become confident citizens in a technological world, able to take or develop an informed interest in scientific matters • recognise the usefulness, and limitations, of scientific method and appreciate its applicability in other disciplines and in everyday life • be suitably prepared for employment and/or further studies beyond Cambridge International A Level in Chemistry. • develop abilities and skills that: • are relevant to the study and practice of science • are useful in everyday life • encourage efficient and safe practice • encourage the presentation of information and ideas appropriate for different audiences and purposes • develop self-motivation and the ability to work in a sustained fashion. • develop attitudes relevant to science such as: • a concern for accuracy and precision • objectivity • integrity • a spirit of enquiry • initiative • insight. • stimulate interest in, and care for, the environment, promote an awareness that: • the study and practice of science are co-operative and cumulative activities, and are subject to social, economic, technological, ethical and cultural influences and limitations • the applications of chemistry may be both beneficial and detrimental to the individual, the community and the environment.

[16] Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Chemistry 9701*, p.11.

	Subject Aims
KCSE Physics[17]	By the end of the course, the learner should be able to: • select and use appropriate instruments to carry out measurements in the physical environment • use the knowledge acquired to discover and explain the order of the physical environment • use the acquired knowledge in the conservation and management of the environment • apply the principles of Physics and acquired skills to construct appropriate scientific devices from the available resources • develop capacity for critical thinking in solving problems in any situation • contribute to the technological and industrial development of the nation • appreciate and explain the role of Physics in promoting health in society • observe general safety precautions in all aspects of life • acquire and demonstrate a sense of honesty and high integrity in all aspects of Physics and life in general • acquire positive attitude towards Physics • acquire adequate knowledge in Physics for further education and/or training.
KCSE Chemistry[18]	By the end of the course, the learners should be able to: • select and handle appropriate apparatus for use in experimental work • make accurate measurements, observations and draw logical conclusions from experiments • observe and appreciate the need for safety precautions during experimental investigations • understand and appreciate the use of chemical symbols and formulae in writing equations • use appropriate chemical terms in describing physical and chemical processes • identify patterns in the physical and chemical behaviour of substances • apply the knowledge acquired to promote positive environmental and health practices • use the knowledge and skills acquired to solve problems in everyday life • apply principles and skills acquired in technological and industrial development • acquire adequate knowledge in chemistry for further education and for training.

[17] The Kenya National Examinations Council (2014), *Kenya Certificate of Secondary Education (KCSE): Examinations Regulations and Syllabuses.*

[18] Ibid.

	Subject Aims
ZIMSEC Physics Forms 5-6[19]	The aims are to: • acquire sufficient understanding and knowledge to become confident citizens in a technological world and be able to take or develop an informed interest in matters of scientific importance. • recognise the usefulness, and limitations, of scientific method and to appreciate its applicability in other disciplines and in everyday life • be suitably prepared for studies beyond A-Level. • develop abilities and skills that are relevant to are useful in everyday life, encourage efficient and safe practice as well as effective communication • develop attitudes relevant to Physics such as concern for accuracy and precision, objectivity, integrity, the skills of enquiry, initiative, innovativeness and inventiveness. • Stimulate interest in, and care for the environment in relation to the environmental impact of Physics and its applications. • Promote an awareness, as guides by Ubuntu/Unhu/Vumunhu philosophy, that: • The study and practice of Physics are co-operative and cumulative activities, and are subject to social, economic, technological, ethical and cultural influences and limitations. • The implications of Physics may be both beneficial and detrimental to the individual, the community and the environment. • Create a sustained interest in Physics so that the study of the subject is enjoying and satisfying.
ZIMSEC Chemistry Forms 5-6[20]	The aims are to: • enable learners to develop fundamental principles of Chemistry for application in life and as a basis for further studies in Chemistry and related disciplines • inculcate in learners the need for safety and protection of the environment in the study of Chemistry • create opportunities for learners to acquire research, experimental, practical, enterprising and technological skills in Chemistry • appreciate the usefulness and limitations of the scientific method in the study of Chemistry • The aims are to: • enable learners to develop fundamental principles of Chemistry for application in life and as a basis for further studies in Chemistry and related disciplines • inculcate in learners the need for safety and protection of the environment in the study of Chemistry • create opportunities for learners to acquire research, experimental, practical, enterprising and technological skills in Chemistry • appreciate the usefulness and limitations of the scientific method in the study of Chemistry • stimulate in learners the desire to apply Chemistry for the benefit of society as guided by the principles of Unhu/Ubuntu/Vumunhu

[19] Zimbabwe Ministry of Primary and Secondary Education (2015), *Physics Syllabus Forms 5-6*.

[20] Zimbabwe Ministry of Primary and Secondary Education (2015), *Chemistry Syllabus Forms 5-6*.

	Subject Aims
NSW HSC Physics[21]	The study of Physics in Stage 6 aims to enable students to develop an appreciation and understanding of the application of the principles of physics, and of the theories, laws, models, systems and structures of physics. It also enables students to apply Working Scientifically skills processes to examine physics models and practices and their applications. The Physics Stage 6 Syllabus involves the study of matter and its motion through space and time, along with related concepts that include energy and force. Physics deals with the study of phenomena on scales of space and time – from nuclear particles and their interactions up to the size and age of the Universe. This allows students to better understand the physical world and how it works, appreciate the uniqueness of the Universe, and participate in navigating and influencing the future. The problem-solving nature of physics further develops students' Working Scientifically skills by focusing on the exploration of models and the analysis of theories and laws, which promotes an understanding of the connectedness of seemingly dissimilar phenomena. Students who study physics are encouraged to use observations to develop quantitative models of real-world problems and derive relationships between variables. Students are required to engage in solving equations based on these models, make predictions, and analyse the interconnectedness of physical entities. The Physics course builds on students' knowledge and skills developed in the Science Stage 5 course and help them develop a greater understanding of physics as a foundation for undertaking post-school studies in a wide range of Science, Technology, Engineering and Mathematics (STEM) fields. A knowledge and understanding of physics often provides the unifying link between interdisciplinary studies. The study of physics provides the foundation knowledge and skills required to support participation in a range of careers. It is a discipline that utilises innovative and creative thinking to address new challenges, such as sustainability, energy efficiency and the creation of new materials.
NSW HSC Chemistry[22]	The study of Chemistry in Stage 6 enables students to develop an appreciation and understanding of materials and their properties, structures, interactions and related applications. Through applying Working Scientifically skills processes, the course aims to examine how chemical theories, models and practices are used and developed. The Chemistry Stage 6 Syllabus explores the structure, composition and reactions of and between all elements, compounds and mixtures that exist in the Universe. The discovery and synthesis of new compounds, the monitoring of elements and compounds in the environment, and an understanding of industrial processes and their applications to life processes are central to human progress and our ability to develop future industries and sustainability. The course further develops an understanding of chemistry through the application of Working Scientifically skills. It focuses on the exploration of models, understanding of theories and laws, and examination of the interconnectedness between seemingly dissimilar phenomena. Chemistry involves using differing scales, specialised representations, explanations, predictions and creativity, especially in the development and pursuit of new materials. It requires students to use their imagination to visualise the dynamic, minuscule world of atoms in order to gain a better understanding of how chemicals interact. The Chemistry course builds on students' knowledge and skills developed in the Science Stage 5 course and increases their understanding of chemistry

21 New South Wales Education Standards Authority (2017), *New South Wales Syllabus for the Australian Curriculum: Physics Stage 6 Syllabus,* pp. 10-12.

22 New South Wales Education Standards Authority (2017), *New South Wales Syllabus for the Australian Curriculum: Chemistry Stage 6 Syllabus,* pp.10-12.

	Subject Aims
	as a foundation for undertaking investigations in a wide range of Science, Technology, Engineering and Mathematics (STEM) related fields. A knowledge and understanding of chemistry is often the unifying link between interdisciplinary studies. The course provides the foundation knowledge and skills required to study chemistry after completing school and supports participation in a range of careers in chemistry and related interdisciplinary industries. It is an essential discipline that currently addresses and will continue to address our energy needs and uses, the development of new materials, and sustainability issues as they arise.

The content of this table was drawn from:

- NSC curriculum aims were drawn from the "specific aims" subsection of the subject curriculum guide.
- IB DP curriculum aims were drawn from the "aims" subsection of the subject curriculum guide.
- Cambridge International AS/A Level curriculum aims were drawn from the "aims" subsection of the subject curriculum guide.
- KCSE aims were drawn from the "General Objectives" bullet point list in the curriculum guide, as there is no specific "aims" or "purpose" subsections.
- Zimbabwe Forms 5-6 aims were drawn from the "aims" subsection of the subject curriculum guide.
- NSW curriculum aims were drawn from the "Rationale" and "Aim" subsections of the subject curriculum guide.

The NSC programme clearly states and differentiates itself from the other curricular by having to deal with the historical generational issues of apartheid, tribalism and a fragmented educational system prior to 1996. Yet the documentation is progressive and generally aspirational making key links throughout using education as a way to break the cycle of poverty and as a way to create globally responsible citizens. Therefore, with this in mind, there are stated aims about inclusivity, and examples that link to South African heritage, industry and development, which resonate with the national sciences curricula in Zimbabwe, Kenya and to some extent in NSW, Australia. This is a distinct difference to the more generic international curricula of IB DP and Cambridge International programmes, where more global themes and internationally recognised examples are used.

That aside, all of the curricula clearly state in their aims that they are seeking to improve knowledge, skills and understanding of scientific concepts, with an emphasis on linking this to everyday or real-world situations. All curricula place emphasis on the following other common themes, regardless of the subject level:

- Learning key theories and laws (in both physics and chemistry)
- The learning and use of specific scientific words, processes and internationally recognised conventions for presenting formulae and scientific nomenclature.
- Using scientific principles in observing, measuring and recording primary data.
- Using some sort of mathematical techniques to help present, analyse or interpret data.
- Using and learning subject specific equations to perform calculations.
- Applying knowledge and skills to solve known or unknown problems.
- A recognition that experiments require specific equipment and the importance of safety with equipment and handling chemicals – using internationally recognised standards for storing and handling chemicals in particular.
- There is also a recognition that sciences provide a greater understanding of the world we live in and perhaps can solve some of the problems we face as a global community.
- A strong reference to the world of science as being an international, English medium subject.

Learning Outcomes

The following table lists the learning outcomes named in each programme's subject documentation. Where curriculum documentation does not explicitly articulate learning outcomes with, for example, a subheading titled "Learning Outcomes", Ecctis have selected lists or extracts which most closely resemble the expected knowledge, skills and competencies that students should have on completion of a programme of study. This is intended to enable comparison between the different curricula as effectively as possible. Where something not labelled "Learning Outcomes" has been used to stand-in for learning outcomes, this is explained in the descriptive analysis underneath the table.

Table 3: Comparison of learning outcomes

	Learning Outcomes
NSC Physical Sciences[23]	The three Learning Outcomes of the Physical Sciences are aligned to the three focus areas identified in the section above on "Scope". Thus, they aim to develop the abilities of: • doing (skills), applying and constructing knowledge (Learning Outcome 1) • knowing (knowledge) (Learning Outcome 2) • being and becoming (values and attitudes) (Learning Outcome 3). **Learning Outcome 1: Practical 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 The thrust of this Learning Outcome is on the doing aspects and the process skills required for scientific inquiry and problem solving. Learners' understanding of the world will be informed by the use of scientific inquiry skills like planning, observing and gathering information, comprehension, synthesising, generalising, hypothesising and communicating results and conclusions. In addition to investigation of natural phenomena, information will be used in problem solving. Problem solving is central to the teaching and learning of Physical Sciences. High order thinking and problem-solving skills are required to meet the demands of the labour market and for active citizenship within communities with increasingly complex technological, environmental and societal problems. Problem solving involves identification and analysis of the problem at hand, and the design of procedures to reach solutions. These skills find application in all spheres of life and in all contexts. **Learning Outcome 2: 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. This Learning Outcome concerns itself with the knowledge of the universe, the world and the environment. Technology, as understood in this outcome, incorporates ways and means of using the physical sciences in the service of humankind, thus enhancing and improving the quality of human life. Underlying this Learning Outcome is the notion of constructing, understanding and applying knowledge in socially, technologically and environmentally responsible ways. The content (facts, concepts, principles, theories, models and laws) and skills studied in Physical Sciences helps learners to gain a better understanding of the world they live in, and to explain physical and chemical phenomena. The context in which learning occurs is important – establishes the purposes for the knowledge, and the ideas and experiences to which the knowledge relates. Progression in this Learning Outcome is ensured through increasing difficulty of concepts and the nature of contexts.

[23] National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Physical Sciences*, pp.23-24.

	Learning Outcomes
	Learning Outcome 3: 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. It is important for learners to understand the scientific enterprise and, in particular, how scientific knowledge develops. Modern science is based on traditions of thought that came together in Europe about 500 years ago. People from other cultures have developed alternative ways of thinking, resulting in different knowledge systems, which are increasingly interactive with Mainstream science. Scientific knowledge is tentative and subject to change as new evidence becomes available and new problems are addressed. The study of historical, environmental and cultural perspectives on science highlights how it changes over time, depending not only on experience but also on social, religious and political factors. Learners at the Further Education and Training stage evaluate the limitations of the explanatory power of scientific models and of different theories to explain phenomena. It is also necessary to help learners make informed decisions and enable them to have a broader understanding of how science relates to their everyday lives, to the environment and to a sustainable future. Acknowledging this interrelationship between science, society and the environment will contribute to active debates and responsible decision making on issues related to technological development, environmental management, lifestyle choices, economics, human health, and social and human development. Scientific and technological advancements affect all aspects of our lives, and it is important for learners to evaluate that impact.

IB DP Physics[24]	The assessment objectives for physics reflect those parts of the aims that will be formally assessed either internally or externally. These assessments will centre upon the nature of science. It is the intention of these courses that students are able to fulfil the following assessment objectives:
	• Demonstrate knowledge and understanding of:
	  • facts, concepts, and terminology
	  • methodologies and techniques
	  • communicating scientific information.
	• Apply:
	  • facts, concepts, and terminology
	  • methodologies and techniques
	  • methods of communicating scientific information.
	• Formulate, analyse and evaluate:
	  • hypotheses, research questions and predictions
	  • methodologies and techniques
	  • primary and secondary data
	  • scientific explanations.
	• Demonstrate the appropriate research, experimental, and personal skills necessary to carry out insightful and ethical investigations

[24] International Baccalaureate Diploma Programme (2016), *Physics Guide*, p. 18.

	Learning Outcomes

IB DP Chemistry[25]	The assessment objectives for chemistry reflect those parts of the aims that will be formally assessed either internally or externally. These assessments will centre upon the nature of science. It is the intention of these courses that students are able to fulfil the following assessment objectives:
	• Demonstrate knowledge and understanding of:
	  • facts, concepts, and terminology
	  • methodologies and techniques
	  • communicating scientific information.
	• Apply:
	  • facts, concepts, and terminology
	  • methodologies and techniques
	  • methods of communicating scientific information.
	• Formulate, analyse and evaluate:
	  • hypotheses, research questions and predictions
	  • methodologies and techniques
	  • primary and secondary data
	  • scientific explanations.
	• Demonstrate the appropriate research, experimental, and personal skills necessary to carry out insightful and ethical investigations

Cambridge International AS/A Level Physics[26]	The assessment objectives listed below reflect those parts of the syllabus aims that will be assessed in the examination. **AO1 Knowledge with understanding** Candidates should be able to demonstrate knowledge and understanding of: • scientific phenomena, facts, laws, definitions, concepts and theories • scientific vocabulary, terminology and conventions (including symbols, quantities and units) • scientific instruments and apparatus, including techniques of operation and aspects of safety • scientific quantities and their determination • scientific and technological applications with their social, economic and environmental implications. **AO2 Handling, applying and evaluating information** Candidates should be able (in words or by using symbolic, graphical and numerical forms of presentation) to: • locate, select, organise and present information from a variety of sources • translate information from one form to another • manipulate numerical and other data • use information to identify patterns, report trends, draw inferences and report conclusions • present reasoned explanations for phenomena, patterns and relationships • make predictions and put forward hypotheses • apply knowledge, including principles, to new situations • evaluate information and hypotheses • demonstrate an awareness of the limitations of physical theories and models.

15 International Baccalaureate Diploma Programme (2016), *Chemistry Guide*, p.18.

26 Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Physics 9702*, p.13.

	Learning Outcomes
	AO3 Experimental skills and investigations Candidates should be able to: • plan experiments and investigations • collect, record and present observations, measurements and estimates • analyse and interpret data to reach conclusions • evaluate methods and quality of data and suggest improvements.
Cambridge International AS/A Level Chemistry[27]	The assessment objectives listed below reflect those parts of the syllabus aims that will be assessed in the examination. **AO1 Knowledge with understanding** Candidates should be able to demonstrate knowledge with understanding in relation to: • scientific phenomena, facts, laws, definitions, concepts, theories • scientific vocabulary, terminology, conventions (including symbols, quantities and units) • scientific instruments and apparatus, including techniques of operation and aspects of safety • scientific quantities and their determination • scientific and technological applications with their social, economic and environmental implications • reasoned explanations for phenomena, patterns and relationships. **AO2 Handling, applying and evaluating information** Candidates should be able (in words or by using symbolic, graphical and numerical forms of presentation) to: • locate, select, organise and present information from a variety of sources • handle information, distinguishing the relevant from the extraneous • manipulate numerical and other data and translate information from one form to another • analyse and evaluate information so as to identify patterns, report trends and draw inferences • construct arguments to support hypotheses or to justify a course of action • apply knowledge, including principles, to new situations • evaluate information and hypotheses. **AO3 Experimental skills and investigations** Candidates should be able to: • plan experiments and investigations • collect, record and present observations, measurements and estimates • analyse and interpret data to reach conclusions • evaluate methods and quality of data and suggest improvements

[27] Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Chemistry 9701*, p.13.

	Learning Outcomes
KCSE Physics[28]	By the end of the course, the learner should be able to: • select and use appropriate instruments to carry out measurements in the physical environment • use the knowledge acquired to discover and explain the order of the physical environment • use the acquired knowledge in the conservation and management of the environment • apply the principles of Physics and acquired skills to construct appropriate scientific devices from the available resources • develop capacity for critical thinking in solving problems in any situation • contribute to the technological and industrial development of the nation • appreciate and explain the role of Physics in promoting health in society • observe general safety precautions in all aspects of life • acquire and demonstrate a sense of honesty and high integrity in all aspects of Physics and life in general • acquire positive attitude towards Physics • acquire adequate knowledge in Physics for further education and/or training.
KCSE Chemistry[29]	By the end of the course, the learners should be able to: • select and handle appropriate apparatus for use in experimental work • make accurate measurements, observations and draw logical conclusions from experiment • observe and appreciate the need for safety precautions during experimental investigations • understand and appreciate the use of chemical symbols and formulae in writing equations • use appropriate chemical terms in describing physical and chemical processes • identify patterns in the physical and chemical behaviour of substances • apply the knowledge acquired to promote positive environmental and health practices. • use the knowledge and skills acquired to solve problems in everyday life • apply principles and skills acquired in technological and industrial development • acquire adequate knowledge in chemistry for further education and for training
ZIMSEC Physics Forms 5-6[30]	Learners should be able to: • demonstrate knowledge about physical phenomena, facts, laws, definitions and concepts of Physics. • follow instructions in practical work in order to manipulate, record observations and analyse data to confirm or establish relationships. • measure and express physical quantities to a given level of accuracy and precision. • Solve real life problems using the scientific method. • use ICT to simulate Physics phenomena, present and analyse Physics data • apply safety measures in all practical work. • Use Physics concepts, principles and techniques in the conservation and sustainable use of the environment.

[28] The Kenya National Examinations Council (2014), *Kenya Certificate of Secondary Education (KCSE): Examinations Regulations and Syllabuses*.

[29] Ibid.

[30] Zimbabwe Ministry of Primary and Secondary Education (2015), *Physics Syllabus Forms 5-6*.

	Learning Outcomes
ZIMSEC Chemistry Forms 5-6[31]	Learners should be able to: • follow instructions in practical work • make and record observations • use ICT Tools and Braille/Jaws software to simulate Chemistry phenomena • apply safety measures in all practical work • present, analyse and interpret data to establish relationships • demonstrate knowledge on facts, laws, definitions and concepts of Chemistry • measure and express quantities to a given level of accuracy and precision • design a practical solution to a real-life problem using knowledge of Chemistry
NSW HSC Physics[32]	The study of Physics in Stage 6 aims to enable students to develop an appreciation and understanding of the application of the principles of physics, and of the theories, laws, models, systems and structures of physics. It also enables students to apply Working Scientifically skills processes to examine physics models and practices and their applications. The Physics Stage 6 Syllabus involves the study of matter and its motion through space and time, along with related concepts that include energy and force. Physics deals with the study of phenomena on scales of space and time – from nuclear particles and their interactions up to the size and age of the Universe. This allows students to better understand the physical world and how it works, appreciate the uniqueness of the Universe, and participate in navigating and influencing the future. The problem-solving nature of physics further develops students' Working Scientifically skills by focusing on the exploration of models and the analysis of theories and laws, which promotes an understanding of the connectedness of seemingly dissimilar phenomena. Students who study physics are encouraged to use observations to develop quantitative models of real-world problems and derive relationships between variables. Students are required to engage in solving equations based on these models, make predictions, and analyse the interconnectedness of physical entities. The Physics course builds on students' knowledge and skills developed in the Science Stage 5 course and help them develop a greater understanding of physics as a foundation for undertaking post-school studies in a wide range of Science, Technology, Engineering and Mathematics (STEM) fields. A knowledge and understanding of physics often provides the unifying link between interdisciplinary studies. The study of physics provides the foundation knowledge and skills required to support participation in a range of careers. It is a discipline that utilises innovative and creative thinking to address new challenges, such as sustainability, energy efficiency and the creation of new materials.

[31] Zimbabwe Ministry of Primary and Secondary Education (2015), *Chemistry Syllabus Forms 5-6*, p.2.

[32] New South Wales Education Standards Authority (2017), *New South Wales Syllabus for the Australian Curriculum: Physics Stage 6 Syllabus*.

	Learning Outcomes
NSW HSC Chemistry[33]	The study of Chemistry in Stage 6 enables students to develop an appreciation and understanding of materials and their properties, structures, interactions and related applications. Through applying Working Scientifically skills processes, the course aims to examine how chemical theories, models and practices are used and developed. The Chemistry Stage 6 Syllabus explores the structure, composition and reactions of and between all elements, compounds and mixtures that exist in the Universe. The discovery and synthesis of new compounds, the monitoring of elements and compounds in the environment, and an understanding of industrial processes and their applications to life processes are central to human progress and our ability to develop future industries and sustainability. The course further develops an understanding of chemistry through the application of Working Scientifically skills. It focuses on the exploration of models, understanding of theories and laws, and examination of the interconnectedness between seemingly dissimilar phenomena. Chemistry involves using differing scales, specialised representations, explanations, predictions and creativity, especially in the development and pursuit of new materials. It requires students to use their imagination to visualise the dynamic, minuscule world of atoms in order to gain a better understanding of how chemicals interact. The Chemistry course builds on students' knowledge and skills developed in the Science Stage 5 course and increases their understanding of chemistry as a foundation for undertaking investigations in a wide range of Science, Technology, Engineering and Mathematics (STEM) related fields. A knowledge and understanding of chemistry is often the unifying link between interdisciplinary studies. The course provides the foundation knowledge and skills required to study chemistry after completing school and supports participation in a range of careers in chemistry and related interdisciplinary industries. It is an essential discipline that currently addresses and will continue to address our energy needs and uses, the development of new materials, and sustainability issues as they arise.

Where learning outcomes were drawn from:

- NSC curriculum learning outcomes were drawn from the across the CAPS document, including the specific aims and the content descriptions.
- IB DP curriculum learning outcomes were drawn from the "assessment objectives" subsection of the subject curriculum guide.
- Cambridge International AS/A Level curriculum learning outcomes were drawn from the "assessment objectives" subsection of the subject curriculum guide.
- KCSE learning outcomes were drawn from the "General Objectives" bullet point list in the curriculum guide, as there is no specific "learning outcomes" subsections.
- Zimbabwe Forms 5-6 learning outcomes were drawn from the "syllabus objectives" subsections of the subject curriculum guide.
- NSW HSC curriculum learning outcomes were drawn from "Objectives" subsections of the subject curriculum guide.

All science programmes seek to advance scientific skills and knowledge, with reference to the level and curriculum material they expect to cover. Ultimately, all curricula look to not only to advance skills and knowledge but foster some sort of enjoyment and lifelong learning of the sciences. Most of the learning objectives fit under three main themes that are common throughout:

Knowledge and understanding

- In all the science curricula, knowledge, understanding and application to real-life situations are key.
- In Physics, knowledge related to scientific

[33] New South Wales Education Standards Authority (2017), *New South Wales Syllabus for the Australian Curriculum: Chemistry Stage 6 Syllabus*.

phenomena, facts, laws, definitions, concepts and theories and standard units of measurement are common across all curricula.
- In Chemistry, knowledge and understanding of chemical properties, structures, and internationally recognised symbols of common elements and compounds.

Handling Data

- Recording and measuring data accurately using the correct measurement units.
- Using mathematical formulae, making accurate calculations and plotting interpreting data in a variety of forms such as tables or graphically.
- Analysis of data, predict, draw conclusions.

Practical skills

All science curricula recognise the importance of students observing first-hand either through teacher-led demonstrations or student led investigations, with the emphasis on safe practices and making accurate observations.

NSC Physical Sciences includes these three themes condensed in some way into the other two themes of: Practical Scientific Knowledge and Problem-Solving Skills and Constructing and Applying Scientific Knowledge. However, the third area that the curriculum seeks to address is how scientific knowledge and understanding comes about to develop questioning and inquiring minds. Although these are not a focus area of the IB DP learning outcomes or Cambridge International learning outcomes they are considered either as part of the Theory of Knowledge (IB), through project work, and in the NSW HSC through practical and depth studies in the sciences, but also the wider programme.

Higher level subjects also look to encourage and give students experiences in problem solving, critical thinking and applying skills and knowledge to unfamiliar situations, some beyond the curriculum that is set. This is quite typical in ZIMSEC Chemistry and Physics, Cambridge International A Levels and IP DP.

Content Areas

The following table summarises the different content areas included within each of the comparison subjects. For ease of comparison, content areas have been grouped by Ecctis. The groups in the table below are labels assigned by Ecctis according to analysis of subject documentation and they do not necessarily reflect the groupings or labels used in the subject documentation for each programme. For the full details of subject content in each programme – listed in the order provided by each programme's documentation – see Appendix.

Table 4: Comparison of content areas

	Year 1 Topics	Subsequent Topics	Optional	Other
NSC Physical Sciences[34]	**Grade 10** **Mechanics** • Motion in 1D • Gravity and mechanical energy **Waves Light and Sound** • Transverse pulses on a string or spring • Transverse waves • Geometrical optics **Electricity and Magnetism** • Magnetism • Electrostatics • Electric circuits **Matter and Materials** • Observing, describing, classifying and using materials - a macroscopic view • Particles substances are made of • The Atom: basic building block of all matter **Chemical Change** • Physical and Chemical Change • Representing chemical change **Chemical systems** • Global cycles • The hydrosphere	**Grade 11** **Mechanics** • Force, momentum and impulse **Waves Light and Sound** • Geometrical optics • Longitudinal waves • Sound • Physics of music **Electricity and Magnetism** • Electrostatics • Electromagnetism • Electric circuits **Matter and Materials** • Electronic properties of matter • Atomic combinations • molecular structure • Atomic nuclei **Chemical Change** • Quantitative aspects of chemical change • Quantitative aspects of chemical change • Types of reaction **Chemical systems** • Exploiting the lithosphere/ Earth's crust • The atmosphere **Grade 12** **Mechanics** • Motion in two dimensions • Work, power and energy	**No optional** topics	Headings in previous columns summarise the topic areas covered from the syllabus in Grades 10-12 3 assessed practical tasks for Physics / Chemistry per academic year.

[34] National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Physical Sciences.*

	Year 1 Topics	Subsequent Topics	Optional	Other
		Waves Light and Sound • Doppler Effect • Colour • 2D and 3D wavefronts • Wave nature of matter **Electricity and Magnetism** • Electrodynamics • Electronics • Electromagnetic radiation **Matter and Materials** • Optical phenomena and properties of materials • Organic molecules • Mechanical properties • Organic macromolecules **Chemical Change** • Rate and Extent of Reaction • Electrochemical reactions • Acids and Bases **Chemical systems** • Chemical industry – resources, needs and the chemical connection		
IB DP Physic[35]	**Core Topics (Standard Level)** • Measurements and uncertainties • Mechanics • Thermal physics • Waves • Electricity and magnetism • Circular motion and gravitation • Atomic, nuclear and particle physics • Energy production	**Additional Higher-Level Topics (AHL)** • Wave phenomena • Fields • Electromagnetic induction • Quantum and nuclear physics	**Optional Topics** 15 hours (SL) 25 hours (HL) at least 1 from: • Relativity • Engineering physics • Imaging • Astrophysics	**Practical scheme of work** • Practical activities • Individual investigation • Group 4 project

[35] International Baccalaureate Diploma Programme (2016), *Physics Guide*.

	Year 1 Topics	Subsequent Topics	Optional	Other
IB DP Chemistry[36]	**Core Topics** • Stoichiometric relationships • Atomic structure • Periodicity • Chemical bonding and structure • Energetics / thermochemistry • Chemical kinetics • Equilibrium • Acids and bases • Redox processes • Organic chemistry • Measurement and data processing	**Additional higher level (AHL)** • Atomic structure • The periodic table—the transition metals • Chemical bonding and structure • Energetics / thermochemistry • Chemical kinetics • Equilibrium • Acids and bases • Redox processes • Organic chemistry • Measurement and analysis	**Option (for extra credit)** • Materials • Biochemistry • Energy • Medicinal chemistry	**Practical scheme of work** • Practical activities • Individual investigation • Group 4 project
Cambridge International AS/A Level Physics[37]	**AS Level** • Physical quantities and units • Measurement techniques • Kinematics • Dynamics • Forces, density and pressure • Work energy and power • Deformation of solids • Waves • Superposition • Electric fields • Current electricity • DC Circuits • Particle and Nuclear physics	**A Level** • Physical quantities and units • Measurement techniques • Motion in a circle • Gravitational fields • Ideal gases • Temperature • Thermal properties of materials • Oscillations • Waves • Communication • Electric Fields • Capacitance • Current Electricity • DC Circuits • Electronics • Magnetic Fields • Electromagnetic induction • Alternating Currents • Quantum Physics • Particle and Nuclear physics	No optional elements either AS or A level	**Practical Element:** Student led practical work should be throughout the course and account for approximately 20% of the teaching time. Not including teacher demonstrations – Assessment in Paper 3 (and Paper 5 -A level) Practical tasks at discretion of each learning institution.

[36] International Baccalaureate Diploma Programme (2016), *Chemistry Guide*.

[37] Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Physics 9702*, p.15.

	Year 1 Topics	Subsequent Topics	Optional	Other
Cambridge International AS/A Level Chemistry[38]	**AS Level** **Physical Chemistry** • Atoms, Molecules and stoichiometry • Atomic structure • Chemical bonding • States of matter • Chemical energetics • Electrochemistry • Equilibria • Reaction kinetics **Inorganic Chemistry** • Periodic table – chemical periodicity • Group 2 • Group 17 • Nitrogen and sulphur **Organic Chemistry and Analysis** • Intro to organic chemistry • Hydrocarbons • Halogen derivatives • Hydroxy compounds • Carbonyl compounds • Carboxylic acids and derivatives • Analytical techniques	**A Level** **Physical Chemistry** • Atomic Structure • Chemical Energetics • Electrochemistry • Equilibria • Reaction Kinetics **Inorganic Chemistry** • Group 2 • Intro to chemistry of transition elements **Organic Chemistry and Analysis** • Intro to organic chemistry • Hydrocarbons • Hydroxy compounds • Carboxylic acids and derivatives • Nitrogen compounds • Polymerisation • Analytical techniques • Organic synthesis	No optional elements either AS or A level	**Practical Element:** Student led practical work should be throughout the course and account for approximately 20% of the teaching time. Not including teacher demonstrations – Assessment in Paper 3 (and Paper 5 -A level) Practical tasks at discretion of each learning institution.
KCSE Physics[39]	• Forces • Thermodynamics • Electricity and Magnetism • Light and Waves • Gas and Fluid Dynamics	• Forces • Thermodynamics • Electricity and Magnetism • Light and Waves • Gas and Fluid Dynamics	No optional elements	Topics summarised under a number of heading areas – elements of each topic covered throughout the course

[38] Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Chemistry 9701*, p.14.

[39] The Kenya National Examinations Council (2014), *Kenya Certificate of Secondary Education (KCSE): Examinations Regulations and Syllabuses.*

	Year 1 Topics	Subsequent Topics	Optional	Other
KCSE Chemistry[40]	• Classification of substances • Atoms and Periodic Table • Structure and Bonding • Gas Laws • Moles • Compounds of carbon, nitrogen, sulphur, chlorine.	• Acids and Bases • Salts • Reactivity • Electrochemistry • Metals • Organic chemistry • Radioactivity	No optional elements	Similar topics – covered across two years but with greater depth and complexity.
ZIMSEC Physics Forms 5-6[41]	**Form 5** **General Physics** • Physical Quantities and Units • Errors and uncertainties **Newtonian Mechanics** • Kinematics • Dynamics • Forces • Work, Energy and Power • Circular Motion • Gravitational Field **Oscillations and Waves** • Oscillations • Waves • Superposition **Electricity and Magnetism** • Electricity • D.C. Circuits • Electric fields • Capacitance	**Form 6** **Electricity and Magnetism** • Electro magnetism • Electromagnetic Induction • Alternating Currents **Electronics** • Analogue Electronics • Digital electronics **Matter** • Phases of Matter • Deformation of Solids • Temperature • Thermal Properties of Materials • Ideal gases • Non-viscous Fluid Flow • Transfer of Thermal Energy **Modern Physics** • Charged Particles • Quantum Physics • Atomic Structure • Radioactivity • Communication	No optional elements	Continuous assessment will be done at the schools from term 1 of Form 5 to the end of term 2 of Form 6. Continuous assessment comprises of Theory tests, Practical tests and a Project. Teachers will be responsible for the continuous assessment of their candidates.

[40] Ibid.

[41] Zimbabwe Ministry of Primary and Secondary Education (2015), *Physics Syllabus Forms 5-6*.

	Year 1 Topics	Subsequent Topics	Optional	Other
ZIMSEC Chemistry Forms 5-6[42]	**Form 5** **Physical Chemistry** • Atoms, molecules and Stoichiometry • Atomic Structure • Chemical bonding **Inorganic Chemistry** • Period 3 periodicity • Group 2 elements • Group IV elements • Group VII elements • Chemistry of nitrogen and sulphur	**Form 6** **Physical Chemistry** • Stoichiometric calculations • Titration **Organic Chemistry** • Hydrocarbons • Hydroxyl Compounds • Carbonyl Compounds • Carboxylic Acids • Nitrogen Compounds • Polymerisation **Applied Chemistry** • Transition elements • Phase equilibria • Environmental Chemistry • Nano Chemistry	No optional elements	**Practical and Coursework** Students complete "coursework" throughout the two years: Form 5 (based on a three term year) • 6 practical tests • 9 Theory tests • 1 project Form 6 (based on two terms with formative assessment in remaining term) • 6 practical tests • 6 Theory tests • 1 project

[42] Zimbabwe Ministry of Primary and Secondary Education (2015), *Chemistry Syllabus Forms 5-6*, pp. 3-40.

	Year 1 Topics	Subsequent Topics	Optional	Other
NSW HSC Physics[43]	Year 11 • Kinematics • Dynamics • Waves and Thermodynamics • Electricity and Magnetism	Year 12 • Advanced Mechanics • Electromagnetism • The Nature of Light • From the Universe to the Atom	Depth Study A minimum of 15 hours of in-class time is allocated in both Year 11 and Year 12. • At least one depth study must be included in both Year 11 and Year 12. • The two Working Scientifically outcomes of Questioning and Predicting and Communicating must be addressed in both Year 11 and Year 12. • A minimum of two additional Working Scientifically skills outcomes, and further development of at least one Knowledge and Understanding outcome, should be addressed in all depth studies.	Depth study allows for differentiation within the curriculum. Offers enrichment activities

[43] New South Wales Education Standards Authority (2017), *New South Wales Syllabus for the Australian Curriculum: Physics Stage 6 Syllabus*.

	Year 1 Topics	Subsequent Topics	Optional	Other
NSW HSC Chemistry[44]	• Properties and Structure of Matter • Introduction to Quantitative Chemistry • Reactive Chemistry • Drivers of Reactions	• Equilibrium and Acid Reactions • Acid/Base Reactions • Organic Chemistry • Applying Chemical Ideas	Depth Study A minimum of 15 hours of in-class time is allocated in both Year 11 and Year 12. • At least one depth study must be included in both Year 11 and Year 12. • The two Working Scientifically outcomes of Questioning and Predicting and Communicating must be addressed in both Year 11 and Year 12. • A minimum of two additional Working Scientifically skills outcomes, and further development of at least one Knowledge and Understanding outcome, should be addressed in all depth studies.	Depth study allows for differentiation within the curriculum. Offers enrichment activities

[44] New South Wales Education Standards Authority (2017), *New South Wales Syllabus for the Australian Curriculum: Chemistry Stage 6 Syllabus*.

Length and Structure of Programmes

The NSC Physical Sciences is a combined Physics and Chemistry curriculum which has a 50:50 split in terms of the material (and assessment). It is unique among these comparison points as it is a three-year programme with helicoidal progression each year: revisiting similar topic areas each year, but in greater depth. All of the other curricula (except KCSE) are two years in length and have a mix of helicoidal learning and material specific for each year of knowledge with no precursory learning, i.e., some topics are only visited once in the curriculum, in either year.

The ZIMSEC Chemistry and Physics in Forms 5 and 6 are two-year curricula, building towards a final advanced level qualification. There is no mid-level exit qualification for either of these subjects (though students may receive an O Level if failing to pass at advanced level).

The IB DP is the only curriculum from the comparators that offers students optional subject material. This would be in the second year of study, and the options may be influenced by the student's personal interest or choice of study pathways into university.

Practical Work

All of the curricula require practical work. Although teacher demonstrations are expected, all of the curricular require student-led work. Some specify the amount of time (percentage), some offer practical suggestions, without being prescriptive some specify students must have completed or have had experience of a certain experiment, (e.g., Titration in Cambridge International Chemistry) – though it doesn't go quite as far as a required practical.

Physics Content

Common Themes: • Forces and Motion • Magnetism • Waves / Sound / Optics • Electromagnetism • Electric Circuits	
Not in NSC • Measurement (as specific topic) • Nuclear / Atomic / Quantum • Astro Physics • Circular motion • Thermal dynamics • Electronics • Optional content	**In NSC (but not elsewhere)**

Chemistry Content

Common Themes: • Atomic structure • Periodic Table • React**ivity**	
Not in NSC • Organic chemistry greater depth material and theory • Optio**nal content**	**In NSC (but not elsewhere)** Global cycles – carbon, hydro cycles The atmosphere The lithosphere Chemical industry

Common Themes:

Some of the topic areas of the NSC are common in all curricula, which are the core elements of all of the Chemistry or Physics curricula.

The NSC curriculum is lacking some of the breadth and depth of some of the other courses, especially the ZIMSEC Chemistry, some elements of the Cambridge International AS Level Chemistry and most of the International A Level course, as well as some of the IB DP and NSW HSC material. The level of depth and complexity is lower in the NSC than some of these comparison curricula in certain topic areas.

From a Physics point of view, again the core elements are similar in all programmes, but the NSC programme lacks breadth and depth in the areas of nuclear physics and circular motion, compared to the International AS level and certainly the International A Level, NSW HSC, and IB DP higher level material.

General Complexity / Level Comment

In the analysis of the syllabi from the different comparator curricula, the NSC Physical Sciences sits below the Cambridge International A Level, IB DP Higher Level and the NSW HSC Physics and Chemistry in terms of level, complexity and depth and breadth of the curriculum. The deviation from the other curricula in making the material more relevant to South Africa, for example the links to chemical industry, mining and extraction are pertinent perhaps in understanding history, current development issues and having a greater need to conserve the South African environment and is perhaps more cross-curricula. The NSC curriculum is deeper in complexity compared to the KCSE Physics and Chemistry curricula.

Assessment Objectives

The table below provides a list of the subject-specific assessment objectives for each subject. Where curriculum documentation does not explicitly articulate assessment objectives with, for example, a subheading titled "Assessment Objectives", Ecctis have selected lists or extracts which most closely resemble the knowledge, skills and competencies that students are assessed on. This is intended to enable comparison between the different curricula as effectively as possible. Where something not labelled "Assessment Objectives" has been used to stand-in for assessment objectives, this is explained in the descriptive analysis underneath the table.

Table 5: Comparison of assessment objectives

	Assessment Objectives
NSC Physical Sciences[45]	**Assessment Objectives:** Level 1: Remembering (15%) Level 2: Understanding (35-40%) Level 3: Applying and Analysing (35-40%) Level 4: Creating and Evaluating (10%) For wider detail on what is assessed, see also the yearly learning outcomes: **Learning Outcome 1: Practical scientific inquiry and problem-solving skills** **Grade 10** **Conduct an investigation** • Plan and conduct a scientific investigation to collect data systematically with regard to accuracy, reliability and the need to control one variable. **Interpret Data and draw conclusions** • Seek patterns and trends in the information collected and link it to existing scientific knowledge to help draw conclusions **Solve Problems** • Apply given steps in a problem-solving strategy to solve standard exercises. **Communicate and present information and scientific arguments** • Communicate information and conclusions with clarity and precision. **Grade 11** **Conduct an investigation** • Plan and conduct a scientific investigation to collect data systematically with regard to accuracy, reliability and the need to control variables. **Interpret Data and draw conclusions** • Seek patterns and trends, represent them in different forms to draw conclusions, and formulate simple generalisations **Solve Problems** • Apply known problem-solving strategies to solve multi-step problems. **Communicate and present information and scientific arguments** • Communicate information and conclusions with clarity and precision. **Grade 12** **Conduct an investigation** • Design, plan and conduct a scientific inquiry to collect data systematically with regard to accuracy, reliability and the need to control variables **Interpret Data and draw conclusions** • Seek patterns and trends, represent them in different forms, explain the trends, use scientific reasoning to draw and evaluate conclusions, and formulate generalisations. **Solve Problems** • Select and use appropriate problem-solving strategies to solve (unseen) problems. **Communicate and present information and scientific arguments** • Communicate information and conclusions with clarity and precision.

[45] National Curriculum Statement (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Physical Sciences*, pp.17-33.

	Assessment Objectives
	Learning Outcome 2: Constructing and Applying Scientific Knowledge **Grade 10** **Recalling and stating specific concepts** • Recall and state basic prescribed scientific knowledge. **Indicating and explaining relationships** • Express and explain prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other. **Applying scientific knowledge** • Apply scientific knowledge in familiar, simple contexts. **Grade 11** Recalling and stating specific concepts • Define and discuss basic prescribed scientific knowledge **Indicating and explaining relationships** • Express and explain prescribed scientific theories, models and laws by indicating the relationship between different facts and concepts in own words. **Applying scientific knowledge** • Apply scientific knowledge in everyday life contexts. **Grade 12** **Recalling and stating specific concepts** • Define, discuss and explain prescribed scientific knowledge. **Indicating and explaining relationships** • Express and explain prescribed scientific principles, theories, models and laws by indicating the relationship between different facts and concepts in own words **Applying scientific knowledge** • Apply scientific knowledge in everyday life contexts. **Learning Outcome 3: The Nature of Science and its relationship to technology, society and the environment.** **Grade 10** **Evaluating knowledge claims and sciences' inability to stand in isolation from fields** • Discuss knowledge claims by indicating the link between indigenous knowledge systems and scientific knowledge. **Evaluating the impact of science on human development** • Describe the interrelationship and impact of science and technology on socio-economic and human development. **Evaluating sciences' impact on the environment and sustainable development** • Discuss the impact of scientific and technological knowledge on sustainable local development of resources and on the immediate environment.

	Assessment Objectives
	Grade 11 **Evaluating knowledge claims and sciences' inability to stand in isolation from fields** • Recognise, discuss and compare the scientific value of knowledge claims in indigenous knowledge systems and explain the acceptance of different claims. **Evaluating the impact of science on human development** • Identify ethical and moral issues related to the development of science and technology and evaluate the impact (pros and cons) of the relationship from a personal viewpoint. **Evaluating sciences' impact on the environment and sustainable development** • Evaluate the impact of scientific and technological knowledge on sustainable development of resources and suggest long-term and short-term strategies to improve the management of resources in the environment. **Grade 12** **Evaluating knowledge claims and sciences' inability to stand in isolation from fields** • Research, discuss, compare and evaluate scientific and indigenous knowledge system knowledge claims by indicating the correlation among them, and explain the acceptance of different claims. **Evaluating the impact of science on human development** • Research case studies and present ethical and moral arguments from different perspectives to indicate the impact (pros and cons) of different scientific and technological applications. **Evaluating sciences' impact on the environment and sustainable development** • Evaluate the impact of scientific and technological research and indicate the contribution to the management, utilisation and development of resources to ensure sustainability continentally and globally

IB DP Physics[46]	The assessment objectives for physics reflect those parts of the aims that will be formally assessed either internally or externally. These assessments will centre upon the nature of science. It is the intention of these courses that students are able to fulfil the following assessment objectives:
	• Demonstrate knowledge and understanding of:
	  • facts, concepts, and terminology
	  • methodologies and techniques
	  • communicating scientific information.
	• Apply:
	  • facts, concepts, and terminology
	  • methodologies and techniques
	  • methods of communicating scientific information.
	• Formulate, analyse and evaluate:
	  • hypotheses, research questions and predictions
	  • methodologies and techniques
	  • primary and secondary data
	  • scientific explanations.
	• Demonstrate the appropriate research, experimental, and personal skills necessary to carry out insightful and ethical investigations

[46] International Baccalaureate Diploma Programme (2016), *Physics Guide*.p.18.

	Assessment Objectives

IB DP Chemistry[47]	The assessment objectives for chemistry reflect those parts of the aims that will be formally assessed either internally or externally. These assessments will centre upon the nature of science. It is the intention of these courses that students are able to fulfil the following assessment objectives:
	• Demonstrate knowledge and understanding of:
	  • facts, concepts, and terminology
	  • methodologies and techniques
	  • communicating scientific information.
	• Apply:
	  • facts, concepts, and terminology
	  • methodologies and techniques
	  • methods of communicating scientific information.
	• Formulate, analyse and evaluate:
	  • hypotheses, research questions and predictions
	  • methodologies and techniques
	  • primary and secondary data
	  • scientific explanations.
	• Demonstrate the appropriate research, experimental, and personal skills necessary to carry out insightful and ethical investigations

Cambridge International AS/A Level Physics[48]	The assessment objectives listed below reflect those parts of the syllabus aims that will be assessed in the examination. **AO1 Knowledge with understanding** Candidates should be able to demonstrate knowledge and understanding of: • scientific phenomena, facts, laws, definitions, concepts and theories • scientific vocabulary, terminology and conventions (including symbols, quantities and units) • scientific instruments and apparatus, including techniques of operation and aspects of safety • scientific quantities and their determination • scientific and technological applications with their social, economic and environmental implications. **AO2 Handling, applying and evaluating information** Candidates should be able (in words or by using symbolic, graphical and numerical forms of presentation) to: • locate, select, organise and present information from a variety of sources • translate information from one form to another • manipulate numerical and other data • use information to identify patterns, report trends, draw inferences and report conclusions • present reasoned explanations for phenomena, patterns and relationships • make predictions and put forward hypotheses • apply knowledge, including principles, to new situations • evaluate information and hypotheses • demonstrate an awareness of the limitations of physical theories and models.

47 International Baccalaureate Diploma Programme (2016), *Chemistry Guide*, p. 18.

48 Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Physics 9702*, p.13.

	Assessment Objectives
	AO3 Experimental skills and investigations Candidates should be able to: • plan experiments and investigations • collect, record and present observations, measurements and estimates • analyse and interpret data to reach conclusions • evaluate methods and quality of data, and suggest improvement
Cambridge International AS/A Level Chemistry[49]	The assessment objectives listed below reflect those parts of the syllabus aims that will be assessed in the examination. **AO1 Knowledge with understanding** Candidates should be able to demonstrate knowledge with understanding in relation to: • scientific phenomena, facts, laws, definitions, concepts, theories • scientific vocabulary, terminology, conventions (including symbols, quantities and units) • scientific instruments and apparatus, including techniques of operation and aspects of safety • scientific quantities and their determination • scientific and technological applications with their social, economic and environmental implications • reasoned explanations for phenomena, patterns and relationships. **AO2 Handling, applying and evaluating information** Candidates should be able (in words or by using symbolic, graphical and numerical forms of presentation) to: • locate, select, organise and present information from a variety of sources • handle information, distinguishing the relevant from the extraneous • manipulate numerical and other data and translate information from one form to another • analyse and evaluate information so as to identify patterns, report trends and draw inferences • construct arguments to support hypotheses or to justify a course of action • apply knowledge, including principles, to new situations • evaluate information and hypotheses. **AO3 Experimental skills and investigations** Candidates should be able to: • plan experiments and investigations • collect, record and present observations, measurements and estimates • analyse and interpret data to reach conclusions • evaluate methods and quality of data, and suggest improvements

[49] Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Chemistry 9701*, p.13.

	Assessment Objectives
KCSE Physics[50]	By the end of the course, the learner should be able to: • select and use appropriate instruments to carry out measurements in the physical environment • use the knowledge acquired to discover and explain the order of the physical environment • use the acquired knowledge in the conservation and management of the environment • apply the principles of Physics and acquired skills to construct appropriate scientific devices from the available resources • develop capacity for critical thinking in solving problems in any situation • contribute to the technological and industrial development of the nation • appreciate and explain the role of Physics in promoting health in society • observe general safety precautions in all aspects of life • acquire and demonstrate a sense of honesty and high integrity in all aspects of Physics and life in general • acquire positive attitude towards Physics • acquire adequate knowledge in Physics for further education and/or training. Further details included in Pages 123-139 of the syllabus
KCSE Chemistry[51]	By the end of the course, the learners should be able to: • select and handle appropriate apparatus for use in experimental work • make accurate measurements, observations and draw logical conclusions from experiments • observe and appreciate the need for safety precautions during experimental investigations • understand and appreciate the use of chemical symbols and formulae in writing equations • use appropriate chemical terms in describing physical and chemical processes • identify patterns in the physical and chemical behaviour of substances • apply the knowledge acquired to promote positive environmental and health practices • use the knowledge and skills acquired to solve problems in everyday life • apply principles and skills acquired in technological and industrial development • acquire adequate knowledge in chemistry for further education and for training Further details included in Pages 140-164 of the syllabus
ZIMSEC Physics Forms 5 -6[52]	**Skill A: Knowledge with understanding** Candidates should be able to demonstrate knowledge and understanding of: • scientific phenomena, facts, laws, definitions, concepts and theories • scientific vocabulary, terminology and conventions (including symbols, quantities and units) • scientific instruments and apparatus, including techniques of operation and aspects of safety • scientific quantities and their determination • scientific and technological applications with their social, economic and environmental implications.

50 The Kenya National Examinations Council (2014), *Kenya Certificate of Secondary Education (KCSE): Examinations Regulations and Syllabuses*.

51 Ibid.

52 Zimbabwe Ministry of Primary and Secondary Education (2015), *Physics Syllabus Forms 5-6*, p.41.

	Assessment Objectives

	Skill B: Handling, applying and evaluating information
	Candidates should be able (in words or by using symbolic, graphical and numerical forms of presentation) to:
	• locate, select, organise and present information from a variety of sources
	• translate information from one form to another
	• manipulate numerical and other data
	• use information to identify patterns, report trends, draw inferences and report Conclusions
	• present reasoned explanations for phenomena, patterns and relationships
	• make predictions and put forward hypotheses
	• apply knowledge, including principles, to new situations
	• evaluate information and hypotheses
	• demonstrate an awareness of the limitations of physical theories and models.
	In answering such questions, candidates are required to use principles and concepts that are within the syllabus and apply them in a logical, reasoned or deductive manner to a new situation
	
	Skill C: Experimental skills and investigations
	Candidates should be able to:
	1. plan experiments and investigations:
	  • defining the problem
	  • choice of equipment and procedure
	  • data collection methods
	  • good design features
	2. collect, record and present observations, measurements and estimates
	3. analyse and interpret data to reach conclusions
	4. evaluate methods and quality of data, and suggest improvements.
	The questions may be based on physics not included in the syllabus content, but candidates will be assessed on their practical skills rather than their knowledge of theory.

ZIMSEC Chemistry Forms 5-6[53]	**1: Knowledge with understanding** Candidates should be able to demonstrate knowledge and understanding of: • scientific phenomena, facts, laws, definitions, concepts, theories • scientific vocabulary, terminology, conventions (including symbols, quantities and units) • scientific instruments and apparatus, including techniques of operation and aspects of safety • scientific quantities and their determination • scientific and technological applications with their social, economic and environmental implications. **2: Handling information, problem solving, synthesis, analysis and evaluation** In words or using other written forms of presentation (e.g., symbolic, graphical and numerical), candidates should be able to: • locate, select, organise and present information from a variety of sources • translate information from one form to another • manipulate numerical and other data • use information to identify patterns, report trends and draw inferences • present reasoned explanations of phenomena, patterns and relationships • make predictions and hypotheses • solve problems, including some of a quantitative nature.

[53] Zimbabwe Ministry of Primary and Secondary Education (2015), *Chemistry Syllabus Forms 5-6*, p. 41.

	Assessment Objectives
	3: Experimental skills, investigations and applications Candidates should be able to: • know how to use techniques, apparatus, and materials (including following a sequence of instructions, where appropriate) • make and record observations and measurements • interpret and evaluate experimental observations and data • plan investigations evaluate methods and suggest possible improvements (including the selection of techniques, apparatus and materials). • solve everyday life challenges, acquire and enhance enterprising skills using the knowledge of chemistry
NSW HSC Physics[54]	**AO1: Skills in working scientifically (60%)** **AO2: Knowledge and understanding of course content (40%)** **Skills** Students: • develop skills in applying the processes of Working Scientifically. **Knowledge and Understanding** Year 11 students: • develop knowledge and understanding of fundamental mechanics • develop knowledge and understanding of energy. Year 12 students: • develop knowledge and understanding of advanced mechanics and electromagnetism • develop knowledge and understanding of the role of evidence and prediction in the development of theories in physics. **Values and Attitudes** Students: • develop positive, informed values and attitudes towards physics • recognise the importance and relevance of physics in their lives • recognise the influence of economic, political and societal impacts on the development of scientific knowledge • develop an appreciation of the influence of imagination and creativity in scientific research

[54] New South Wales Education Standards Authority (2017), *New South Wales Syllabus for the Australian Curriculum: Physics Stage 6 Syllabus*.

	Assessment Objectives
NSW HSC Chemistry[55]	**AO1: Skills in working scientifically (60%)** **AO2: Knowledge and understanding of course content (40%)** **Objectives:** **Skills** Students: • develop skills in applying the processes of Working Scientifically. **Knowledge and Understanding** Year 11 students: • develop knowledge and understanding of the fundamentals of chemistry • develop knowledge and understanding of the trends and driving forces in chemical interactions. Year 12 students: • develop knowledge and understanding of equilibrium and acid reactions • develop knowledge and understanding of the applications of chemistry. **Values and Attitudes** Students: • develop positive, informed values and attitudes towards chemistry • recognise the importance and relevance of chemistry in their lives • recognise the influence of economic, political and societal impacts on the development of scientific knowledge • develop an appreciation of the influence of imagination and creativity in scientific research.

Some programmes do not specifically name "assessment objectives". The content of this table was drawn from:

- NSC curriculum assessment objectives were drawn from the subsection of the subject curriculum guide discussing "cognitive levels". In order to supplement this with further information, detail was also drawn on learning outcomes.
- IB DP curriculum assessment objectives were drawn from the "assessment objectives" subsections of the subject curriculum guides.
- Cambridge International AS/A Level curriculum assessment objectives were drawn from the "assessment objectives" subsections of the subject curriculum guides.
- KCSE assessment objectives were drawn from the "General Objectives" bullet point list in the curriculum guide, as there is no specific "assessment objectives" subsection.
- Zimbabwe Forms 5-6 assessment objectives were drawn from the "assessment objectives" subsections of the subject curriculum guide.
- NSW curricula assessment objectives were drawn from "Objectives" and "Outcomes" subsections of the subject curriculum guide.

All science programmes seek to advance scientific skills and knowledge, with reference to the level and curriculum material they expect to cover. The prime objective therefore of assessment in all of the curricula is to ensure that students have gained sufficient knowledge and skills in a particular subject and specified topic areas.

55 New South Wales Education Standards Authority (2017), *New South Wales Syllabus for the Australian Curriculum: Chemistry Stage 6 Syllabus*.

Knowledge Principles

The principles of assessing of knowledge in all curriculum programmes is ensuring that students can recall processes, theories, and scientific principles. This is common in all programmes and is relevant to the level and complexity of the curriculum. Students also require mathematical knowledge to recall a formula or at least know the correct formula to use from a given sheet.

Skills Assessment Principles

The assessment of skills in relation to each curriculum is broadly similar, though any differences are mainly related to the depth and complexity of each curriculum. All curricula want to assess practical skills as well as whether students can do so with greater independence and with greater awareness of working safely. All curricula also seek to assess, to some degree, how students can manipulate, interpret, and draw conclusions from set data.

The main differences highlighted stem from comparing the NSC to the Cambridge International A Level, ZIMSEC, and IB DP. Particularly for the highest grades in these programmes, reference is made to the assessment of critical thinking and analysis skills. In particular, the use of calculations, data, and reasoning skills to form a judgement or conclusion. The extent to which curricula assess these higher-level skills is more notable than in the NSC. Although the NSC focuses on assessing students' higher order skills through practical assessments and questions based on data given in tables and graphs which require conclusions being made by analysing and synthesising such data, the analysis of all subjects across the qualifications review indicates that some other programmes give more emphasis on the extent and depth to which these higher order thinking skills are assessed.

Problem Solving skills are specifically and explicitly outlined in the assessment principles of the NSC, perhaps more so that the other curricula, with clear assessment examples to help demonstrate whether a student has reached a particular required level. This is a strength of the curriculum.

Assessment Methods

The table below demonstrates some key features of the methods used to assess each subject.

Table 6: Comparison of assessment methods

	Assessment Method (External) and Weighting	Assessment Method (Internal) and Weighting	Use of Question Types
NSC Physical Sciences[56]	**Paper 1: Physics** • 3 hours • 150 marks **Paper 2: Chemistry:** • 3 hours • 150 Marks Final Assessment = 75% of final mark	School Based Assessment Material 100 marks worth 25% of overall mark. Externally set with guidance for adaptation Externally moderated	**Paper 1: Physics** • 10 questions (2 marks each) • Multiple choice Remainder of paper mix of short answer, calculations and longer answer questions **Paper 2: Chemistry** • 10 questions (2 marks each) • Multiple choice Remainder of paper mix of short answer, calculations and longer answer questions
IB DP Physics[57]	**Standard Level** Paper 1: • 45 minutes • 20% weighting • 30 marks Paper 2: • 75 minutes • 40% weighting • 50 marks Paper 3: • 1 hour • 20% weighting • 35 marks **Higher Level** Paper 1: • 1 hour • 20% weighting • 40 marks Paper 2: • 135 minutes • 36% weighting • 95 marks Paper 3: • 75 minutes • 24% weighting • 45 marks	The internal assessment requirements for physics are worth 20% of the final assessment consists of: One scientific investigation. The individual investigation should cover a topic that is commensurate with the level of the course of study. Student work is internally assessed by the teacher and externally moderated by the IB. The performance in internal assessment at both SL and HL is marked against common assessment criteria, with a total mark out of 24.	**Standard Level** Paper 1: • 100% Multiple Choice questions • Non-calculator Paper 2: • Short-answer questions • extended-response questions on core material. Paper 3 Section A: • one data-based question • several short-answer questions on experimental work. Section B: • short-answer questions • extended-response questions from one option. **Higher Level** Paper 1 • 40 multiple-choice questions on core and AHL, about 15 of which are common with SL. • Non-calculator

[56] Department of Basic Education Republic of South Africa (2017), *Physical Sciences: Examination Guidelines Grade 12; National Curriculum Statement* (2011), *Curriculum and Assessment Policy Statement Grades 10-12 Physical Sciences*.

[57] International Baccalaureate Diploma Programme (2016), *Physics Guide*, pp. 134-135.

	Assessment Method (External) and Weighting	Assessment Method (Internal) and Weighting	Use of Question Types
			Paper 2 • Short-answer questions • extended-response questions on the core and AHL material. Paper 3 • Questions on core, AHL and option material. Section A: • one data-based question • several short-answer questions on experimental work. Section B: • short-answer questions • extended-response questions from one option.
IB DP Chemistry[58]	**Standard Level** Paper 1: • 45 minutes • 20% weighting • 30 marks Paper 2: • 75 minutes • 40% weighting • 50 marks Paper 3: • 1 hour • 20% weighting • 35 marks **Higher Level** Paper 1: • 1 hour • 20% weighting • 40 marks Paper 2: • 135 minutes • 36% weighting • 90 marks Paper 3: • 75 minutes • 24% weighting • 45 marks	The internal assessment requirements for chemistry are worth 20% of the final assessment consists of: One scientific investigation. The individual investigation should cover a topic that is commensurate with the level of the course of study. Student work is internally assessed by the teacher and externally moderated by the IB. The performance in internal assessment at both SL and HL is marked against common assessment criteria, with a total mark out of 24. Internal Assessment Weighting: (using IB set guidelines) • Engagement : 8% • Exploration : 25% • Analysis: 25% • Evaluation : 25% • Communication 17%	**Standard Level** Paper 1: • 100% Multiple Choice questions Paper 2: • Short-answer questions • extended-response questions on core material. Paper 3 Section A: • one data-based question • several short-answer questions on experimental work. Section B: • short-answer questions • extended-response questions from one option. **Higher Level** Paper 1: • 40 multiple-choice questions on core and AHL, about 15 of which are common with SL Paper 2 • Short-answer questions • extended-response questions on the core and AHL material. • Paper 3 questions on core, AHL and option material.

[58] International Baccalaureate Diploma Programme (2016), *Chemistry Guide*, pp. 173-190.

	Assessment Method (External) and Weighting	Assessment Method (Internal) and Weighting	Use of Question Types
			Section A: • one data-based question • several short-answer questions on experimental work. Section B: • short-answer questions • extended-response questions from one option.
Cambridge International AS/A Level Physics[59]	**AS Level** Paper 1: • 75 minutes • 40 marks • A Level weighting of 15.5% • AS Level weighting of 31% Paper 2: • 75 minutes • 60 marks • A Level weighting of 23% • AS Level weighting of 46% Paper 3: • 2 hours • 40 marks • Timed Laboratory experiment consisting of 2 experiments from different parts of the curriculum • A level weighting of 11.5% • AS Level weighting of 23% **A Level only** Paper 4: • 2 hours • 100 marks • 38.5% weighting	Paper 3: Detailed externally set, yet internally marked using prescriptive mark scheme – generic and specific provided by Cambridge International – subject to exam conditions. Paper 3 will be a timetabled, laboratory-based practical paper, focusing on the following experimental skills: • manipulation, measurement and observation • presentation of data and observations • analysis, conclusions and evaluation. Two questions, each of 1 hour and each of 20 marks. The first question will be an experiment requiring candidates to collect data, to plot a graph and to draw conclusions. The second question will be an experiment requiring candidates to collect data and to draw conclusions but may or may not include the plotting of a graph.	Paper 1 • Multiple Choice (4 options) Paper 2 AS Level: • Structured questions • short and longer answer questions of varying marks Paper 3: • Advanced practice skills (see internal assessment column) Paper 4: • Variable number of free responses • long and short answer questions. Paper 5 • Two or more questions totalling 30 marks. • Candidates will be answer two equal value questions pertaining to skills of planning, analysis and evaluation on practical investigation of a given problem. • Questions may not be highly structured: candidates will be expected to answer using extended, structured writing, illustrated with appropriate diagrams, flow charts, tables or equations. • Candidates may be asked to express a prediction in the form of a written hypothesis linking independent and dependent variables, or in the form of a graph showing the expected outcome.

[59] Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Physics 9702*, pp. 9, 47-54.

	Assessment Method (External) and Weighting	Assessment Method (Internal) and Weighting	Use of Question Types
	Paper 5: • 75 minutes • 30 marks • 11.5% weighting Specific rules in place for candidates taking AS / A Level to ensure relevant exam series taken. AS Level – Papers 1-3 A Level – Papers 1-5	Confidential experimental details sent to centres several weeks in advance. Assessment weightings details sent with each assessment series.	
Cambridge International AS/A Level Chemistry[60]	**AS Level** Paper 1: • 1 hour • 40 marks • A level weighting of 15.5% • AS Level weighting of 31% Paper 2: • 75 minutes • 60 marks • A level weighting of 23% • AS Level weighting of 46% Paper 3 • 2 hours • Timed Laboratory experiment papers 1 or 2 parts with 2 or 3 questions • 40 marks total • A level weighting of 11.5% • AS Level weighting of 23% **A Level only** Paper 4: • 2 hours • 100 marks • Weighting of 38.5%	Paper 3: Detailed externally set, yet internally marked using prescriptive mark scheme – generic and specific provided by Cambridge International – subject to exam conditions. Students complete 2 tasks: One question will be an observational problem in which the candidate will be asked to investigate an unknown. The other question or questions will be quantitative: either volumetric analysis or measurement of a quantity, e.g., the enthalpy change of a reaction, mass change on heating, changing the rate of a reaction or measuring a gas volume. Confidential experimental details sent to centres several weeks in advance. Assessment weightings details sent with each assessment series.	Paper 1 • Multiple Choice (4 options) Paper 2 AS Level: • Structured questions • mix of short and longer answer questions of varying marks Paper 3 • Advanced practice skills (see internal assessment column) Paper 4 • Variable number of free responses • long and short answer questions. Paper 5 • will consist of two or more questions totalling 30 marks. • Candidates will be required to design an experimental investigation of a given problem. Such questions may not be highly structured: candidates will be expected to answer using extended, structured writing, illustrated with appropriate diagrams, flow charts, tables or equations.

[60] Cambridge International Examinations (2016), *International AS and A Level: Syllabus: Cambridge International AS and A Level Chemistry 9701*, pp.47-60.

	Assessment Method (External) and Weighting	Assessment Method (Internal) and Weighting	Use of Question Types
	Paper 5: • 75 minutes • 30 marks • Weighting of 11.5% Specific rules in place for candidates taking AS / A Level to ensure relevant exam series taken. AS Level – Papers 1-3 A Level – Papers 1-5		• Candidates may be asked to express a prediction in the form of a written hypothesis linking independent and dependent variables, or in the form of a graph showing the expected outcome.
KCSE Physics[61]	3 Exam Papers Paper 1: • 2 hours • 80 marks Paper 2: • 2 hours • 80 marks Paper 3: • 2.5 hours • 40 marks	Paper 1: • Heat and Mechanics Paper 2: • Optics • Waves • Electricity • Magnetism • Modern Physics. Paper 3: • Physics practical test. • The paper will consist of two compulsory questions, which may be set from any part of the syllabus.	Paper 1 Section A: • 25 marks • Compulsory short answer questions Section B: • 55 marks • A minimum of four and a maximum of six compulsory structured questions, • each question carries a maximum of 15 marks Paper 2 Section A: • 25 marks • Compulsory short answer questions Section B: • 55 marks • A minimum of four and a maximum of six compulsory structured questions, • each question carries a maximum of 15 marks Paper 3: • Physics Practical Test. • 2 compulsory questions from any part of the syllabus.

[61] The Kenya National Examinations Council (2014), *Kenya Certificate of Secondary Education (KCSE): Examinations Regulations and Syllabuses*.

	Assessment Method (External) and Weighting	Assessment Method (Internal) and Weighting	Use of Question Types
KCSE Chemistry[62]	3 Exam Papers: Paper 1: • 2 hours • 80 marks • Chemistry theory Paper 2: • 2 hours • 80 marks • Chemistry theory. Paper 3: • 2¼ hours • 40 marks • Chemistry practical test	Paper 3: • Chemistry practical test. • The test may be drawn from any topic in the syllabus	Paper 1: • The paper will consist of compulsory short answer questions. Paper 2: • The paper will consist of compulsory structured questions • testing any of the topics in the syllabus Paper 3: • Chemistry Practical Test. • 2 compulsory questions from any part of the syllabus.
ZIMSEC Physics Forms 5-6[63]	70% Summative assessment Paper 1: • 1 hour • Multiple Choice • 40 marks • 11% weighting Paper 2: • 90 minutes • Structured • 60 marks • 17% weighting Paper 3: • 2 hours 30 minutes • Free response • 100 marks • 28% weighting Paper 4: • 2 hours 30 minutes • Practical • 50 marks • 14% weighting	30% continuous assessment (this is the equivalent of Paper 5) Paper 5: • 110 marks	Paper 1: • Multiple choice questions. (40 Marks) • Knowledge and Understanding 18/40 • Handling, applying and evaluating information 22/40. Paper 2: Section A: • Structured questions • short and longer answer responses (60 Marks) • Knowledge and Understanding 25/60 • Handling, applying and evaluating information 35/60. Paper 3: • Free response (100 marks) • Knowledge and Understanding 45/100 • Handling, applying and evaluating information 55/100. Paper 4: • Practical (50 marks) • Experimental skills and investigations (50/50) Paper 5 • A series of standardised tests in practical, theory and a project during 2 years.

[63] Zimbabwe Ministry of Primary and Secondary Education (2015), *Physics Syllabus Forms 5-6*.

	Assessment Method (External) and Weighting	Assessment Method (Internal) and Weighting	Use of Question Types
ZIMSEC Chemistry Forms 5-6[64]	70% summative assessment Paper 1: • 1 hour • 40 Marks Paper 2: • 1 hour 30 mins • 60marks Paper 3: • 90 marks – scaled to a mark out of 50 Paper 4: • 2 hours 30mins • 50 marks Practical Examination	30% continuous assessment Form 5 • worth 10% of final grade Form 6 • worth 20% of final grade	Paper 1: Theory: • 40 compulsory multiple-choice items. • 30 items will be of the direct choice type and 10 of the multiple completion types. • Each question shall have 4 response items. Paper 2: Theory: • 6 compulsory structured questions, 10 marks each. • Learners answer all the questions on the question paper Paper 3: Theory 4 sections: Section A: • based mainly on the Physical Chemistry Section B: • based mainly on Inorganic Chemistry Section C: • based mainly on Organic Chemistry Section D: • based mainly on the Applications of Chemistry Leaners will be required to answer a total of 6 questions: • 2 questions from Section A • 1 question from Section B • 2 questions from Section C • 1 question from Section D. The paper will be marked out of 90 and scaled down to a mark of 50. Paper 4: • Practical Examination • 3 compulsory structured questions based on qualitative analysis, quantitative analysis and planning/design. • The paper will be marked out of 50 marks.

64 Zimbabwe Ministry of Primary and Secondary Education (2015), *Chemistry Syllabus Forms 5-6*.

	Assessment Method (External) and Weighting	Assessment Method (Internal) and Weighting	Use of Question Types
NSW HSC Physics[65]	Continuous Assessment throughout Year 11 and 12 – with smaller regular assessments that build a portfolio of teacher assessed evidence, plus a yearly examination **External Examination:** • 3 hours plus 5 mins reading time • 100 marks	**Year 11** • Skills in working scientifically 60% weighting • Knowledge and understanding of course content 40% 3 assessment tasks: • No more than 1 task formal exam. • 1 depth study • Individual tasks with grading weighting between 20-40% per task **Year 12** Mandatory weightings are: • Working scientifically 60% • Knowledge and understanding of course content 40% 4 assessment tasks: • Only one task formal exam – with weighting of 30% • Individual tasks with weightings 10-40% • Depth study 20-40%	The external paper will consist of two sections. Section 1 (20 marks) • There will be objective-response questions • 20 marks. Section 2 (80 marks) • Questions may contain parts • There will be 20 to 25 items. • At least two items will be worth 7 to 9 marks.
NSW HSC Chemistry[66]	Continuous Assessment throughout Year 11 and 12 – with smaller regular assessments that build a portfolio of teacher assessed evidence, plus a yearly examination **External Examination:** • 3 hours plus 5 mins reading time • 100 marks	**Year 11** • Skills in working scientifically 60% weighting • Knowledge and understanding of course content 40% 3 assessment tasks: • No more than 1 task formal exam. • 1 depth study	The external paper will consist of two sections. Section 1 (20 marks) • There will be objective-response questions to the value of 20 marks. Section 2 (80 marks) • Questions may contain parts. • There will be 20 to 25 items. • At least two items will be worth 7 to 9 marks.

[65] New South Wales Education Standards Authority (2017), *New South Wales Syllabus for the Australian Curriculum: Physics Stage 6 Syllabus*.

[66] New South Wales Education Standards Authority (2017), *New South Wales Syllabus for the Australian Curriculum: Chemistry Stage 6 Syllabus*.

	Assessment Method (External) and Weighting	Assessment Method (Internal) and Weighting	Use of Question Types
		• Individual tasks with grading weighting between 20-40% per task Year 12 4 assessment tasks: • Only one task formal exam – with weighting of 30% • Individual tasks with weightings 10-40% • Depth study 20-40% **Year 12** Mandatory weightings are: • Working scientifically 60% • Knowledge and understanding of course content 40%	A data sheet, formulae sheet and Periodic Table will be provided. NESA-approved calculators may be used. There will be approximately equal weighting given to Modules 5 to 8. Questions relating to Working Scientifically Skills will be integrated throughout the examination.

Assessment is the key part in ensuring the standard set for each of the curricula compared. The nature of the taught material means that there is a mixture of knowledge, skills, and practical work assessed in different ways across the subjects analysed. Generally, the assessment structure for Physics and Chemistry in each programme is broadly the same in terms of the way that each subject is assessed separately, though the specific marks and weightings vary between subjects.

Formal Examinations

The key element in each programme is the presence of formal examinations. In each of the curricula, there is always an element of continuous assessment for teachers to maintain judgments on whether students are grasping the material taught. However, the use of formalised assessments, that count towards the students' final grade are important here. The South African NSC Physical Sciences is the only curriculum that combines both the physics and chemistry element, whereas all other sciences are treated separately, though may make up a wider qualification. The documentation states equal weighting for the physics and chemistry elements, in terms of teaching material and assessment, and therefore the overall mark is made up of 50:50 of each subject.

The most common form of assessment is the terminal exam, which a cumulation of the material covered across the whole curriculum. This is used commonly in all programmes. The main differences are use of assessments at the end of each year, for example in Cambridge International and NSW HSC, where accreditation can be gained part way through, either as a separate qualification or the credit gained forms part of the final assessment. This has the benefit of giving students an accredited exit point, especially if they are not planning to major in sciences at university.

Types of questions and weightings

All of the science curricula use different types of questions to assess different skills and knowledge. All have an element of short answer or multiple-choice questions, testing simple recall of

knowledge or the application of a skill. The NSC Physical Sciences is the only examination that has two marks for multiple choice answers, where every other exam it is one mark.

All programmes have a mix of short and longer response questions, typically based around a set scenario, with information or data to interpret, manipulate or analyse. Generally, recall type questions carry the lowest marks (1 or 2) consistently across all of the curricula, whereas higher level skills making calculations, analysing, problem solving, or giving some evaluative processes are worth a higher number of marks.

Practical Work

Also key in all curricula is the presence of practical work. The physical sciences lend themselves to practical and experiential learning opportunities and form a key part in understanding the theoretical elements. The assessment of practical work is either externally or internally set, and then either assessed through examination, external or internally with external moderation. The model adopted by NSC Physical Sciences is similar to that in Kenya with externally set, though adaptable tasks that are teacher marked and externally moderated. This is slightly different to the Cambridge International and ZIMSEC programmes, where the practical tasks are prescriptively set with their own equally prescriptive mark scheme, which is assessed externally through a timed practical exam, overseen by schools with pupils' papers sent for external marking. The NSW HSC curriculum, in particular, takes a very different approach of assessing practical skills in a more hands on fashion with teachers setting on-going practical work for each topic area with internal and external moderation processes to assess these elements. IB DP also allows teachers to set "appropriate" experiments for assessment, but like the Cambridge International system, has a very prescriptive mark scheme, though teachers submit these results after internal marking and moderation.

Coursework – Teacher Assessment

The IB DP and NSW HSC have an assessed coursework element to the make-up of the final student grade. This is actively encouraged as either individual research, write-up from field work, or group project work. This element can be student led and is an integral part of the identity of each of these. IB DP gives guidelines and descriptors as to how marks are awarded. Whereas at the other end of the scale the NSW curriculum has the most flexibility of what is assessed and how it is assessed.

Each of the different elements on their own has merit and limitations, and key areas to consider from an awarding body would be in regard to consistency and fairness in the standardisation of teacher assessed work.

Key Findings

Learning Outcomes and Assessment Objectives

Scope

The scope of the learning outcomes from the NSC Physical Sciences with the other curricula is broadly similar. With the main differences focusing on the national and cultural values in each country and the broader issues around language, access to education and development. This is particularly true in the national curricula of: South Africa, Zimbabwe, Kenya and to a lesser extent Australia. This is less so in the more international curricula of IB DP and Cambridge International.

The learning outcomes focus of all curricula are based on scientific knowledge, skills, and practical observations – with all curricula keen to develop scientifically aware citizens of the future. The learning outcomes of each curriculum are strongly embedded to the level and the progression points for the qualification, with a view to enabling students to major in sciences at tertiary institutions.

Skills Coverage

Each of the different curricula present the skills being assessed in slightly different way with some being more prescriptive than others and some giving a clearer breakdown than others.

Data has been extracted as best possible from some of the different curricula and summarised in the table below. The assessment objective weightings could not be extracted at this level of detail from KCSE and NSW documentation.

	NSC Physical Sciences PAPER 1 (PHYSICS)	NSC Physical Sciences PAPER 2 (CHEMISTRY)	Cambridge International Chemistry	Cambridge International Physics	IB DP Chemistry and Physics	ZIMSEC Chemistry	ZIMSEC Physics
Recall	15 %	15 %	55%	48%	50%	42%	42%
Comprehension	35 %	40 %					
Analysis, Application	40 %	35 %	45%	52%	50%	58%	58%
Evaluation, Synthesis	10 %	10 %					

In the case of NSC Physical Sciences, the breakdown is relatively straightforward and clear, using the breakdown from the syllabus document. In other curricula, the breakdown is not quite as prescriptive and broken down in the same way, so some of the skills have been combined and should be taken as approximate values as some include the practical exam material or school-based assessment. Where there is more than one paper the percentages are made up using the raw score totals of each skill area out of the total marks.

The breakdown of knowledge recall and comprehension skills is 50% in NSC Physical Sciences, this is broadly in-line with Cambridge International sciences, IB DP sciences and slightly higher than ZIMSEC Forms 5-6 sciences.

Generally, in the Cambridge International A Levels and IB DP, there is still going to be an element of knowledge recall and demonstrating understanding of the basic skills covered in each. However, to differentiate the higher grades and greater complexity and breadth of material covered, there is a greater focus in assessments such analysis, problem solving and evaluating information in a greater proportion.

Information for KCSE and NSW HSC was not clearly available in this format and therefore have been excluded from this table. For example, NSW HSC breaks the skills covered in each unit covered, though the weighting of each skill assessment varies. Therefore, NSC Physical Sciences assessment of skills is broadly in-line with other international curricula in terms of the proportion of the breakdown of knowledge and recall, compared with higher level skills.

Content and Structure

Scope

Of the different curricula in this comparison, the content of the NSC Physical Sciences curriculum sits somewhere above, in complexity and of subject matter, KCSE Physics and Chemistry, however it is not as complex in terms of depth and breadth as the Cambridge International A Level, IB DP Physics and Chemistry (particularly Higher Level), ZIMSEC Chemistry and Physics advanced level and the full NSW HSC courses. The elements of the NSC Physical Sciences overlap most closely to the Cambridge International AS Level material (Physics and Chemistry), the core material of the IB DP (Physics and Chemistry) and the core elements of the NSW HSC programme. There is no exit qualification in Zimbabwe between O Level and advanced level.

It is worth making note that NSC Physical Sciences is the only curriculum that covers three school years in its preparation period, and some of the material covered in the first year (Grade 10) does overlap with some of the material in the KCSE sciences, though progresses in greater depth.

The NSC subject structure is very different compared to all of the other curricula, in that it is much more helicoidal in its approach, meaning that the same topic areas are revisited in each year, but each time in greater depth and complexity.

Sequencing

As one subject, "Physical Sciences", it seems that the teaching sequence either has a physics or chemistry focus, for example, looking at the teaching scheme and the assessments that would be carried out throughout the curriculum, each term has alternating chemistry or physics taught content and then a school-based assessment focus. Most likely all other curricula will have physics and chemistry topics running concurrently in different timetabled periods throughout a week and taught as separate discrete subjects.

The NSC subject structure is very different compared to all of the other curricula, in that it is much more helicoidal in its approach, meaning that the same topic areas are revisited in each year, but each time in greater depth and complexity. So, for physics for example, in each year there will be an element of mechanics, element of waves, light and sound, etc. Similarly, in chemistry every year there will be chemical changes, matter and materials etc. This has the benefit of being able to show progression year-on-year, by demonstrating that each year progressively becomes more challenging in terms of skills and knowledge, and that assessment in grade 12 is the culmination of the curriculum.

With all of the other science curricula there is a sequence of teaching units in the schemes of learning, which offer logical progression, though could be taught slightly out-of-sequence if teachers or schools wished to suit. The ZIMSEC subjects, as two-year curricula where students

have to cover all of the material, could effectively be taught more flexibly as the assessment is at the end of the period of study. Cambridge International sciences, IB DP sciences and NSW HSC have clearly defined what will be taught in each year. The sequencing of the material and what is actually taught school-to-school may vary slightly.

Skills Coverage

The skills coverage in all of the sciences curricula demonstrate the need for a good mathematical skills base. As the depth becomes greater, particularly throughout the Cambridge International A Level and HL IB DP Physics, the mathematical requirements are greater in their complexity, demonstrating the skills progression. Good analytical skills are also required beyond the mathematical requirements, as the very best students should be able to make the calculations, but then evaluate what they mean in relation to the situation presented.

The information analysed by Ecctis for NSC Physical Sciences, ZIMSEC sciences, NSW HSC sciences and KCSE presented English medium courses and have a strong emphasis on developing English language skills, as well as science skills. The Cambridge International and IB DP less so, as they are English medium for an international market, but with a greater emphasis in the full curriculum for written analytical answers, the need to write up reports, problem solve, complete project work and make more detailed arguments based on data where needed.

Certainly, all of the curricula examined seek to develop internationally recognised scientific methodology, and make students aware of the process of discovery, investigation and critical analysis, especially as many students will progress to major in these sciences at university. The Cambridge International A Level, IB DP Higher Level and ZIMSEC Forms 5-6 are particularly strong in these areas.

When completing practical investigations, the progression from teacher-led to student-led investigations is strong within all curricula, though the KCSE tends to be more teacher-led and simpler in nature, reflecting the lower level of skills covered initially. NSW HSC has the greatest flexibility and range of skills covered, with students encouraged to complete practical work, group work, independent research, and group project work where appropriate and work perhaps with the greatest autonomy compared to the other comparison points. IB DP science subjects, as part of the wider curriculum, encourage cross-curricular development, focusing as much on how knowledge and skills develop as well as the what the skills and knowledge are themselves (IB DP - Theory of Knowledge component), there is also the extra element of project / group work expected to complete this qualification.

Assessment

Structure

The way that each of the programmes is assessed and the final grades awarded differs between all of the programmes. All programmes have an element of practical assessment and formal exams, and some programmes place emphasis on other coursework such as independent research.

In the NSC Physical Sciences programme, the final grade (Grade 12) examination is based on all the Grade 12 content together with some topics from the Grade 11 syllabus. The assessment is then based on one paper each of chemistry and physics at the end of the period of study. Other curricula, which place their emphasis on terminal formative assessments, have at least two exam papers, which may have a different focus, i.e. a different part of the curriculum or different skills being tested. None of the practical work assessments of Grade 11 are included in the final Grade 12 assessment.

The Cambridge International curricula differ significantly as they offer assessment credit at

the end of the first year, which can be credit outright or be carried forward towards further higher-level accreditation. The method of assessment, although predominantly exam-based, includes an assessed practical element.

The other main differences between the way that NSC Physical Sciences are assessed are that there are no optional elements of questions, such that are found in the ZIMSEC, Cambridge International, and IB DP sciences curricula, particularly at the higher level, where students who have studied optional elements may be working towards a particular university major, such as engineering.

All of the exam papers, in all of the curricula, include a multiple-choice element, although NSC Physical Sciences awards two marks per question compared to the one in all of the papers. In testing recall knowledge, most of the questions are short answer, looking for a keyword or phrase, some carry just one mark, others may require some elaboration for one or two marks more.

In testing skills, all of the exam papers reviewed use a scenario-based question, for example, an experiment, sample results, a graph, data that requires a calculation. This can then be combined into multiple step questions; i.e., use the data to explain, analyse, relate to a theory.

The approach to assessment across the different curricula places a strong emphasis on formative assessment though the methods used in each country varies. The NSC Physical Sciences show the following similarities:

- NSC Physical Sciences is similar to KCSE, NSW HSC and IB DP programmes in being part of a wider qualification – with credit points being gained towards the wider qualification.
- All programmes assess key scientific knowledge, with a focus on skills development appropriate to the subject material.
- All programmes have a strong emphasis on a formal assessment approach.
- NSC Physical Sciences has a strong practical assessment stream common within all curricula, accounting for 11.2% of the overall assessment grade for the Grade 12 NSC, and this comes via the school-based assessments. Each curriculum has slight variations on their practical weightings.
- There is strong emphasis in all programmes on offering a wide range of question types in exams to formally assess skills and knowledge, with multiple choice, short answer, and reasoning skills evident in similar proportions throughout the examination papers viewed.

Marking

Standardisation and consistency with marking and assessment across different educational establishments is the key underlying driver to ensure validity and legitimacy of each of the qualifications either nationally or internationally. Hence all of the curricula have clearly set out assessment policies and very prescriptive marking policies and mark schemes. For exams, particularly final exams, to ensure fairness, papers are marked anonymously using external markers with a process of quality assurance that helps with the consistency and standardisation. Markers may be teachers; however, teachers would not mark their own candidates work.

In analysis of the different exam papers / marking schemes, the following observations were made:

NSC marking strategy is very clear for both paper 1 (Physics) and Paper 2 (Chemistry).[67] Papers are marked externally. To score full marks, the correct answer and the correct working / use of formulae, supporting the correct answers and correct units score the full marks for the

[67] Department of Basic Education South Africa (2017), *Physical Sciences, Grade 12. Examination Guidelines*, pp. 33-37.

question; writing just the correct answer does not score full marks. A clear penalty system used for combinations of correct / incorrect processes is given in the guidance. Also included are detailed examples and sample marks given for a mix of correct, partially correct, and incorrect answers – giving as much support as possible to markers, teachers, and ultimately transparency to students who can see that there is a consistent and fair approach across the sciences subjects.

The majority of the questions in KCSE require an answer and short responses – with keywords sought to gain the marks. Review of the exam material showed that this is a lower level of skills assessment.

Cambridge International AS/A Levels (both Physics and Chemistry) provides a comprehensive set on mark schemes, with the general principles of working closely with the mark scheme, marking positively, only giving whole marks and for open response questions, accepting that there may be a large range in answers, but ultimately not to mark to grade levels or grade level descriptors. Where there are multiple marks awarded for questions, a selection of keywords and phrases are included for the markers to look out for. The mark schemes for International A Level sciences awards marks for showing understanding, a method, process as well as the correct answer. Students can be awarded any number of marks up to the full total for the question. There is a mix of question types; for short answers - 1 or 2 marks per question. There are marks for the answer and then a relevant keyword / phrase for explanation. Higher level questions carry more marks and may be split into a number of parts with overall up to 20 marks, but smaller parts with different tasks. Students can still gain credit in multi-part questions gaining follow-through marks if the correct process has been applied, but the wrong numbers or calculation has taken place in an earlier part of the question.

The main difference comes from the use of criteria-based assessment in the assessment of practical work, particularly in the IB DP project work. Although this only a relatively small percentage of the overall mark and a prescriptive guide is provided on converting statements into a numerical score. There are some other criteria-based statements used in the Cambridge International Sciences and IB DP documentation – giving an indication of what typifies their type of learners, or generally learners at a particular level, but these do not relate directly to the assessment marking process.

Skills Coverage

Each curricula clearly states what skills are being assessed and the weightings of these skills / distribution across the examination papers. The NSW HSC is the curriculum most unlike all of the others with the skills covered in each module or sub-unit very clearly defined. In particular, each module in the NSW documentation starts with a detailed breakdown of the skills to be covered, with suggestions for assessment of these. The assessment of scientific skills is through a combination of practical and examinations and relies more on teacher-led assessment and building a portfolio of work.

The NSC Physical Sciences is certainly the clearest in terms what skills are being taught in each year, and how they are assessed and linked to the learning objectives. It also shows the clearest progression of skills from one year to the next. So, although the same skill area is being revisited, it is being approached at the next level. Also, areas are suggested for skills development, whether through a more theoretical approach, such as using prepared data to manipulate and analyse to draw a conclusion, or through hands-on practical tasks.

In NSW HSC sciences and IB DP sciences there are suggested independent research opportunities and more opportunities to develop critical thinking, which can be student led, and analytical skills which are more about creating or problem solving than the more prescriptive and centralised investigations set by some other awarding bodies.

Practical skills are integral to all of the curricula and the way they are assessed either through examinations or in controlled conditions has merit and limitations. Even though students may not have carried out all of the skills practically, they will have been exposed to the theoretical elements of the practical tasks.

Documentation

For details of the subject guides, assessment materials, and mark schemes used throughout this appendix (including years of publication), see **7. Bibliography** in the body of the report.

Notes

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