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QUALIFICATIONSPECIFICATION SECTION A						
QUALIFICATION DEVELOPER	Botswana International University of Science and Technology					
TITLE	Bachelor of Science in Chemistry (Environmental and Analytical Chemistry)			**NCQF LEVEL**	7	
FIELD	Natural, Mathematical and Life Sciences		**SUB-FIELD**	Environmental and Analytical Chemistry		
New qualification	✓	Review of existing qualification				
SUB-FRAMEWORK	General Education		TVET		Higher Education	✓
QUALIFICATIONTYPE	Certificate		Diploma		Bachelor	✓
	Bachelor Honours		Master		Doctor	
CREDIT VALUE					522	

1. RATIONALE AND PURPOSE OF THE QUALIFICATION

1.1. Rationale of the Qualification

The need for Environmental and Analytical Chemistry in Botswana, the region and internationally has been indicated in various reports, surveys, and documents. According to the Botswana National Research, Science and Technology Plan

Final Report (DRST, 2005), Botswana's economic development has been heavily dependent on mining and as such Botswana has undertaken research aimed at contributing to improved value addition and beneficiation of natural resources through research in areas such as (i) Research into mining bi-product utilisation, (ii) Research into Environmentally Cleaner Production Technologies and (iii) Chemical Sciences research into improved extraction and processing technologies. The provision of Environmental and Analytical Chemistry program puts Botswana in a strategic position in so far as analysis of the chemicals

arising from mining is concerned, their environmental impact as well as benefits that can be derived from useful by products emanating from mining activities. The Botswana Human Resources Development Council (Top Occupations in high Demand as of December 2016) released a list of occupations in demand and the list was made to align with both current and future labour market trends. The HRDC has also taken note of the fact that as the economy grows, there will be emerging skills needed especially in a knowledge-based economy which is driven by science, technology, innovation, research and development. The HRDC report lists Environmental and Analytical Chemistry professions as among those in demand such as Water Chemists, Soil Scientists, Environmental Protection Professionals, Chemical Technicians, Research Technicians and Science and Technology Researchers.

The industry stakeholders have endorsed this qualification during an industrial advisory board meeting held on 19th July 2019. The industry stakeholders have indicated that this qualification will bridge the gap between analytical chemistry and environmental science since the analytical chemists will have a background knowledge on environmental issues when they tackle persistent problems such as pollution of air, soil and water.

In addition, the Global Competitiveness Report (2016-2017) lists Botswana at position number 107 out of 138 countries based on the 'Availability of scientists and engineers', an indication of high demand of scientists such as Environmental Analytical Chemists. Water is a scarce natural resource in Botswana, owing to the country being semi-arid (Botswana Climate Variability and Change: Understanding the Risks Draft Policy Note 2010) and this has put constraint to economic development and growth for the agricultural (irrigation) and mining sectors. As a result, future growth of these sectors will require much more emphasis on re-use of wastewater, rainwater harvesting and desalination. Environmental and Analytical Chemists will be critical in these regard in ensuring that re-use of wastewater and harvested rainwater are safe for use and consumption by people and animals. In 2003, underground water provided 55.5% of the national demand for fresh water while rivers and dams provided 5.6 and 39.9% respectively. This implies that the need to use treated effluent (or 'new' water) should be escalated so as to meet the water supply demand in Botswana. The Environmental and analytical chemistry profession is also described as of short supply at medium level (Department of research, science, and technology (DRST) 2009). According to the report, environmental and analytical chemistry professionals are required in the mining, energy, agriculture, environmental affairs, pollution control and health sectors. Chemical Technicians are also in short supply in the education sector. Analytical chemists and environmental chemists are among the 42 professional categories enjoying scarce skill allowance in the civil service owing to their scarcity in Botswana. Analytical

and environmental chemists, including chemistry teachers enjoy the highest scarce skill allowance of 40% to basic salary and are categorized in the same bracket as medical doctors, dentists, engineers, architects, quantity surveyors, pharmacists. Laboratory analytical chemists are also categorized as a profession with acute scarcity (Tsa Badiri Consultancy 2015). Most of researchers in Botswana hold Bachelors/Masters degrees as opposed to Doctorate degrees (DRST 2009). There is therefore a need to upgrade Analytical and Environmental Chemistry researchers to Honours, Masters and PhD levels. During the National Development Plan (NDP) 11 the Botswana Government will continue to grow the economy through beneficiation of minerals, various agricultural products, and indigenous products / herbs. The proposed Qualification will help to diversify the economy as there is potential for growth in the manufacturing industry. Botswana as a cattle country has potential for vibrant soap and leather industries. In addition to this, Botswana has the potential to develop IV fluids and drugs. Botswana can also convert its huge supply of coal into high value petroleum and chemical products. This could replace imported fuels and other chemicals. These activities require analytical chemists and environmental chemists. There is high demand environmental and analytical chemistry graduate applies regionally and internationally. The Republic of South Africa has a high demand for Environmental analysts and analytical chemistry researchers. Other area of high demand in South Africa which relies on the Environmental and analytical chemists include Research and Development Managers, Environmental Managers, Safety, Health, Environment and Quality Practitioners, Air Pollution Analyst, Water Quality Analyst, Physical Science Teachers, Natural Science Teachers, Chemistry Technicians, Physical Science Technicians, Forensic Technicians, Food and Beverage Technicians, Manufacturing Technicians and Water Inspectors (South Africa Government Gazette 2014).

Environmental and analytical chemists are also required in the oil sector as 11 African countries have proven oil reserves (https://www.sablog.kpmg.co.za/2014/04/african-chemical-industry-hidden-opportunity/). In the United States of America, the demand for Environmental Chemists and Analytical Chemical Technicians grew by 3.1% and 4.2%, respectively in 2014 (Rovner, 2014). Environmental and Analytical Chemists are in demand in Australia (http://www.visabureau.com/australia/anzsco/jobs/chemist-jobs-australia.aspx). In Europe, shortages of Chemical Technicians are expected (C and E News, 93 issue 24, pp34-26, 2005). The proposed Qualification is in line with vision 2036 as it will promote the following pillars (i) a knowledge based economy - the use of science, technology and innovation to propel economies to high levels of efficiency is key to supporting socio-economic development (ii) promote human capital development-as the country will have developed an internationally competitive workforce that is productive and has international exposure and (iii) Education and skills development-Botswana society will be

knowledgeable with relevant quality education that is outcome based, with an emphasis on technical and vocational skills as well as academic competencies and (iv) Ecosystem functions and services-providing research for the identification and development of marketable products. It will also produce environmental and analytical chemists (and Chemical Technicians) for the region as well as the international community. The Qualification is in line with the vision of the Botswana International University of Science and Technology's vision "… To provide globally competitive and high-quality science, engineering, and technology academic Qualifications in order to produce employment-ready graduates through excellence in teaching, learning, research, collaborative partnerships, industry linkages and community engagement." It is also in line with the University's vision "…to be a Center of Excellence, a world-class research institution, and the Science, Engineering, and Technology University of choice in the region, and the African continent."

1.2. Purpose of the Qualification

The purpose of this qualification is to produce graduates who have knowledge, competences, and skills to:

1.2.1. Address Botswana's domestic sustainable development goals of 'clean water and sanitation' by providing analytical methods and techniques that can address drinking water quality in Botswana.

1.2.2. Address waste management in Botswana such as wastewater, domestic waste, and industrial effluent to help Botswana achieve one of its domestic sustainable development goals of 'sustainable cities and waste management'.

1.2.3. Conduct applied research to address various environmental problems facing the country and the world at large.

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1.2.4. Be able to qualify for higher education and training in Environmental and Analytical Chemistry or related field in support of the life-long learning principle.

2. ENTRY REQUIREMENTS (including access and inclusion)
2.1. NCQF Level 4 – Certificate IV (General Education/technical and vocational education and training (TVET) with passes in Chemistry, Mathematics plus one other science subject or equivalent. 2.2. Applicants who do not meet the above criteria but possess relevant industry experience may be considered through Recognition of Prior Learning (RPL) and Credit Accumulation and Transfer (CAT) policies for access. This consideration will be done following guidelines of the ETP which are aligned with BQA/National policies.

3. QUALIFICATIONSPECIFICATION SECTION B	
GRADUATE PROFILE (LEARNING OUTCOMES)	**ASSESSMENT CRITERIA**
3.1. Generate specialized scientific information on analysis of air, soil, and water samples.	3.1.1. Design appropriate procedures for generating selected environmental sampling, sample preparation and analysis of data applied with due concern for bias and for any ethical and safety considerations. 3.1.2. Conduct appropriate forms of enquiry by applying standard procedures in environmental and analytical chemistry analysis of wastewater, soil, and air such as experimental or computational techniques. 3.1.3. Record quantitative and qualitative data accurately and truthfully from analysis of environmental samples such as wastewater, soil or air following defined standard operating procedures. 3.1.4. Analyze data and scientific evidence pertaining to analysis of air, soil water and draw valid arguments and conclusions from such analysis.

3.2. Demonstrate advanced and specialized key scientific reasoning skills and evidence towards application of analytical chemistry in solving problems affecting the environment.	3.2.1. Judge and assess the best analytical methodology for carrying out analysis of a particular environmental pollutant such as heavy metals in wastewater. 3.2.2. Exemplify logical thinking in environmental sampling, sample preparation and analysis of soil, air, and water samples and identify naïve and flawed scientific data. 3.2.3. Discriminate inductive (effect to cause or specific to general) and deductive (cause to effect or general to specific) reasoning pertaining to environmental sampling, sample handling, sample preparation and analysis of environmental samples. 3.2.4. Perform hypothetico-deductive reasoning on environmental pollution from point source pollution sources such as industries and agricultural activities. 3.2.5. Infer the cause-effect relations in the face of some level of uncertainty or gap in available analytical data corresponding to a particular environmental problem such as water pollution. 3.2.6. Deduce upon thinking and reasoning process and demonstrate that an environmental pollution problem has been adequately solved using analytical techniques.
3.3. Communicate specialized scientific understanding of sampling, sample preparation and analytical technique used for sample analysis effectively and efficiently to an audience.	3.3.1. Use scientific language correctly to produce clear and coherent written state of the environment documents, sampling, sample preparation and analysis procedures which follow appropriate scientific conventions. 3.3.2. Present scientific data on state of environmental pollution verbally in front of others. 3.3.3. Use appropriate referencing conventions when writing state of the environment and analytical methods development, avoiding plagiarism, and respecting intellectual property.
3.4. Solve unpredictable and	3.4.1. Solve, analyze, and formulate concrete and abstract

complex scientific problems such as waste management affecting the environment by optimization of analytical methodologies.	environmental problems and formulate analytical methods for solving such problems in familiar and unfamiliar contexts. 3.4.2. Be able to operate analytical chemistry equipment such as spectrophotometer, spectrofluorometer, chromatography, voltammetry, and electrochemical equipment to analyze pollutants in soil, air and water. 3.4.3. Apply knowledge of theory to develop analytical methods in order to solve particular real-world problem such as pollution and waste management. 3.4.4. Integrate knowledge from environmental science and analytical chemistry in solving environmental pollution problems.
3.5. Apply effective Information and Communication Technology (ICT) skills to illustrate and describe an analytical chemistry technique towards solving an environmental pollution and waste management issues.	3.5.1. Critique, analyze and modify the quality of data derived from a variety of sources which may be contradictory or divergent that relate to analytical methodologies applied to sampling, sample preparation and sample analysis of pollutants in soil, air, and water. 3.5.2. Perform tasks related to advanced computer literacy skills such modelling and mapping of polluted sites. 3.5.3. Critically assess the validity of ICT solutions for problems posed by environmental pollution such as plotting graphs on excel spreadsheet to demonstrate environmental pollution trend. 3.5.4. Use ICT that is appropriate to solving environmental pollution problems, e.g., for: computational applications; simulation applications; pattern recognition; automation and control; managing large volumes of environmental pollution data.
3.6. Work effectively as a member of a team in specialized environmental and analytical	3.6.1. Provide evidence of successful and effective contributions in teamwork relating to assignments on environmental pollutants sampling, sample handling, preparation, and

chemistry projects or investigations.	selection of appropriate analytical tool for analysis. 3.6.2. Communicate the outcomes of environmental pollution remediation team work effectively and with respect to the contributions of each team member. 3.6.3. Apply organizational skills in managing teamwork.
3.7. Apply specialized scientific knowledge and ways of thinking to societal issues, considering ethical and cultural considerations.	3.7.1. Identify environmental and analytical chemistry knowledge that is relevant to current societal issues such as sample preparation methodologies that do not produce toxic chemicals into the environment. 3.7.2. Critically evaluate public information dealing with current state of the environment and the application of analytical methods in solving such problems. 3.7.3. Make ethically and culturally sensitive decisions on the effects of scientifically based activities such as sampling of human body fluids for evaluation of transport of environmental pollutant in the food chain. 3.7.4. Identify the socio-economic impact of state of environment interventions such as soil remediation and reclamation efforts on the society. 3.7.5. Apply scientific knowledge regarding application of analytical methods to solving environmental issues for the direct benefit of others such as waste management to improve hygiene and quality of air for people living in close proximity to landfills.

3.8. Apply appropriate analytical chemistry research methods to solve environmental problems such as pollution and waste management	3.9.1. Select appropriate environmental sampling, sample handling, preparation, and analysis methodologies, collect accurate and relevant data and evaluate recent literature and discuss and present the results on a specific pollutant found in air, soil, and water. 3.9.2. Evaluate the significance of the results in context by comparing theoretical predictions on the state of the environment with published data. 3.9.3. Reflect upon the implications of the findings on environmental problems under consideration. 3.9.4. Analyse results of an analytical experiment on pollution, waste management or other type of research investigation and draw valid conclusions and evaluate the level of uncertainty in these results and expected outcomes. 3.9.5. Propose recommendations on pollution remediation, waste management strategies and analytical method optimization. 3.9.6. Use analytical chemistry statistics to manipulate precise and intricate ideas to construct logical arguments. 3.9.7. Engage and critique current research practices and techniques related to environmental pollution and the application of analytical chemistry to mitigate environmental problems.
3.10 Undertake a research project in Environmental and Analytical Chemistry to address pollution in air, water and soil.	3.10.1. Perform scientific experiments on the state of environmental pollution and remediation strategies other types of research investigation which produce meaningful results. 3.10.2. Undertake appropriate analysis of the data on pollution control, management and remediation strategies and discuss results in terms of published scientific literature and present them in the form of a written scientific report.

4. QUALIFICATIONSTRUCTURE SECTION C			
FUNDAMENTAL COMPONENT Subjects / Units / Modules /Courses	**Title**	**Level**	**Credits**
	General Chemistry Level I	5	12
	General Chemistry Level II	6	12
	General Biology Level I	5	12
	General Biology Level II	6	12
	Pre-calculus	5	24
	General Physics	5	24
	Introduction to computing	5	12
	Academic Literacy Skills	5	12
	Technical Report Writing	6	12
	Introduction to Entrepreneurship	6	6
	Business and Entrepreneurship	7	24
CORE COMPONENT Subjects / Units / Modules /Courses	Organic Chemistry	6	12
	Analytical Chemistry	6	12
	Inorganic Chemistry	6	12
	Physical Chemistry	6	12
	Calculus	6	24
	Physics	6	12
	Statistics	6	12
	Biophysical Environment	6	12
	Human Environments	6	12
	Work Based Learning	7	24
	Instrumental Analysis	7	24
	Separation Science	7	12
	Physical and Chemical Equilibria	7	12
	Statistics and Chemometrics	7	6
	Environmental Analytical Chemistry	7	24

	Electroanalytical Chemistry	7	12
	Quality Assurance	7	12
	Remote Sensing	7	12
	Environmental Impact Assessment	7	12
	Geographic Information Systems and Databases	7	12
	Surface Chemistry	7	12
	Environmental Hazards & Waste Management	7	12
	Environmental Pollution & Remediation	7	12
	Research Methods	7	6
	Miscellaneous Techniques	7	12
	Project	7	12
	Catchment Processes & Management	7	12
ELECTIVE COMPONENT Subjects / Units / Modules /Courses	N/A		

Rules of combinations, Credit distribution (where applicable):

Table 1. Credit Distribution

NCQF Level	**Credit Contribution**
Level 5	96
Level 6	162
Level 7	264
Total Credits	**522**

Table 2. Credit Contribution for Fundamental and Core modules

Component	Credit Contribution
Fundamental modules	162
Core Modules	360
Total	**522**

5. ASSESSMENT AND MODERATION ARRANGEMENTS

ASSESSMENT ARRANGEMENTS

5.1. Formative Assessment

All formative assessments shall be aligned to learning outcomes. Formative assessment will contribute 50% towards final grade.

5.2. Summative Assessment

Summative assessment will contribute 50% of the final grade. Assessors must be BQA registered and accredited.

MODERATION ARRANGEMENTS

There will be internal and external moderation for the qualification.
Moderators must be BQA registered and accredited. Both internal and external moderation will be done in-line with institutional and national policies

6. RECOGNITION OF PRIOR LEARNING (if applicable)

Candidates may submit evidence of prior learning and current competence and/or undergo appropriate forms of RPL assessment for the award of credits towards the qualification in accordance with applicable RPL policies and relevant national-level policy and legislative framework.

7. PROGRESSION PATHWAYS (LEARNING AND EMPLOYMENT)

This qualification is designed to facilitate vertical and horizontal progression both locally and internationally.

7.1. Horizontal Progression

Graduates may progress horizontally in the following qualifications.

• Bachelor of Science in Chemistry (Materials and Applied Chemistry)
• Bachelor of Science in Chemistry (Drug Discovery and Development)
• Bachelor of Science Forensic Science

7.2. Vertical progression

Graduates from this qualification may progress to level 9 qualifications such as.

• Bachelor of Science and Honours in Chemistry (Environmental and Analytical Chemistry)
• Bachelor of Science and Honours in Chemistry (Materials and Applied Chemistry)
• Bachelor of Science and Honours in Chemistry (Drug Discovery and Development)

7.3. Employment Pathways

Graduates of the qualification may find employment in a range of public and private organisations for the following posts.

- Water Chemists
- Soil Scientists
- Environmental Protection Professionals
- Chemical Technicians
- Research Technicians
- Science and Technology Researchers
- Environmental Managers
- Safety, Health, Environment and Quality Practitioners
- Air Pollution Analyst
- Food and Beverage Technicians
- Quality Assurance Technician in Manufacturing Processes
- Water Inspectors

8. QUALIFICATION AWARD AND CERTIFICATION

8.1. Qualification Award

To qualify for the qualification award and certification, a candidate must:

A candidate will be awarded a qualification in Bachelor of Science in Chemistry (Environmental and Analytical) upon meeting the minimum of 522 credits as prescribed in the rules of combination.

8.2. Certification

A certificate and transcript will be issued to graduates upon successful completion of the qualification.

9. REGIONAL AND INTERNATIONAL COMPARABILITY

9.1. REGIONAL COMPARABILITY

9.1.1. University of Nairobi, Bachelor of Science in Environmental Chemistry (Kenya), Kenya National Qualifications Framework, (KNQF), Level 7.

The Kenya National Qualification Framework provides Bachelor of Science in Environmental Chemistry as a four-year qualification with minimum total credits of 480. The entry requirements to this program include, Kenya Certificate of Secondary Education (KCSE) or equivalent qualifications, with passes in at least three subjects in either of the following two alternatives (A or B), Alternative A includes passes in Chemistry, Physical Sciences, Biology, Physics and Mathematics and Alternative B includes three passes in either Physical Sciences, Biological Sciences, Geography and Mathematics. Advanced Certificate of Education (KACE), or equivalent qualification with at least two principal passes (of which one must be in chemistry).

Ordinary Diploma/Higher National Diploma or equivalent qualifications in the sciences with at least a pass Science/Technical Diploma from Teachers Training Colleges or equivalent qualifications in the sciences. A science/technology-based degree or a non-science based degree with a minimum of C+ in chemistry or its equivalent from an institution recognized by the University c) candidates who may not have fulfilled conditions in (b) above may be considered for admission provided they present evidence of having undertaken and passed relevant bridging courses from an institution recognized by the University and MUST have scored at least grade C in the subject(s) for which bridging has been undertaken.

The aim of the degree program is to produce graduates who are well grounded in chemistry and other

basic sciences as well as environmental and business management.

In relation to our proposed qualification, the entry requirements are similar to those of the qualification compared with. Fundamental modules such as Entrepreneurship and Business Management will be required as compulsory modules as in the compared qualification. Contrastingly, the proposed qualification incorporates communication and writing skills to better equip learners with writing and communication skills. In addition, statistics and mathematics will also be required as core modules for the learning outcomes to develop an in-depth knowledge and skills in environmental and analytical chemistry profession.

9.2. INTERNATIONAL COMPARABILITY

9.2.1. Newcastle University (Australia), BSc Environmental and Analytical Chemistry & Sustainable Resource Management -AQF (Australian Qualifications Framework (AQF), level 7)

The Australian admission requires an A-level Chemistry plus other science and Mathematics. Thus, A-level will be equivalent to level 5 of the proposed qualification. This program lists other soft skills modules as core such as (i) Professional Employment Skills and Professional Scientific thinking. Statistics and Mathematics have also been covered as core modules for this qualification.

In relation to our proposed qualification, fundamental modules such as Entrepreneurship, Business and Academic Literacy will be required as compulsory. In addition, statistics and mathematics will also be required as core modules for the learning outcomes to develop an in-depth knowledge and skills in environmental and analytical chemistry profession.

9.2.2. Universiti Malaysia Terengganu, BSc Analytical and Environmental Chemistry-QAA (Level 7)

This is another similar qualification for duration of 31/2 years. Similarly, for this qualification, there are

three entry requirements for the qualification being diploma or other qualification recognized as equivalent by the Malaysian Government and approved by the Institut Pengajian Tinggi Awam **(**IPTA) Senate which is also referred to as the Private Higher Educational Institutions (PHEIs). For learners with matriculation which is A 'levels equivalent, candidates should have obtained at least Grade C with a GPA of 2.00 in either Chemistry or Engineering Chemistry. High school leavers should have passed Malaysian Higher School Certificate (STPM) with at least: Grade C (2.00) General Studies and Grade C (2.00) in two (2) other subjects and a minimum Level 1 (Band 1) in the Malaysian University English Test (MUET) and at least Grade C (CGPA 2.00) at STPM level in Chemistry.

Similar to the proposed qualification ggraduates of this qualification will have the knowledge and skills not only in the various fields of chemistry but have special skills in analytical chemistry methods and environments and use all the latest equipment and instruments in the field. Some of that can be pursued by graduates of this qualification are as a researcher, chemist for product development, process development, and environmental analysis and forensics. Graduates can also venture into the field of teaching as a lecturer or teacher.

The exit outcomes of the two equivalent qualifications cover similar scope and depth and are aligned to exit-level descriptors typical to this level and type of qualification, as well as competencies required for registration and accreditation with professional bodies such as Royal Society of Chemist (RSC) and American Chemical Society (ACS). However, what sets this qualification apart from the qualifications examined is that there are integration entrepreneurial and business attributes to the proposed qualification which equips the graduate with the requisite skills to be able to start their own businesses if they cannot find employment.

10. REVIEW PERIOD

Review period is 5 Years or as and when the need arises.

11. Other information – please add any supplementary information to help the application for this qualification for NCQF Registration.

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CODE (ID)			
REGISTRATION STATUS	BQA DECISION NO.	REGISTRATION START DATE	REGISTRATION END DATE
LAST DATE FOR ENROLMENT		LAST DATE FOR ACHIEVEMENT	