وزارة التعليم

رؤية عمان 2040

Chemistry Curriculum Framework

Grades (11-12) - Bilingual Program

2026\2027

الإطار المنهجي لمادة الكيمياء

الصفوف (11–12) – البرنامج ثنائي اللغة

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المديرية العامة للمؤسسات التعليمية الخاصة

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Introduction

Science plays a major role in the evolution of knowledge. It empowers us to use creative and independent approaches to problem solving. It arouses our natural curiosity and enables us to meet diverse and ever expanding challenges. It enhances our ability to inquire, seek answers, research and interpret data. These skills lead to the construction of theories and laws that help us to explain natural phenomena and exercise control over our environment. Science is, thus, an integral component of a balanced education.

This curriculum framework focuses on the content essential for preparing students to be engaged and productive citizens. A good foundation in the sciences will help citizens to respond to the challenges of a rapidly changing world using the scientific approach. It addresses, in addition to a specific knowledge base, the development of related skills and attitudes. Critical thinking, enquiry and reasoning are emphasized to ensure that students develop the ability to work creatively, think analytically and solve problems. The curriculum framework also ensures that students become aware of their moral, social, and ethical responsibilities, as well as, the benefits intrinsic to the practical application of scientific knowledge to careers in the scientific field. Teaching these standards requires teaching methods that are varied and experiential. Effective lessons will be concertd and incorporate with: Practical work and the science standards, the place of information and communications technology in the science standards, teaching about science, technology and society, the mathematical requirements of the science standards.

The overall aims of science standards are that students should:

1. Develop and sustain an interest in science and its applications.
2. Have a sound and systematic knowledge of important scientific facts, concepts and principles, and possess the skills needed to apply these in new and changing situations in a range of personal, domestic, industrial and environmental contexts.
3. Recognize the importance of the application of scientific knowledge in the modern world and be aware of the moral, ethical, social and environmental implications.
4. Develop relevant attitudes, such as a concern for accuracy and precision, objectivity, integrity, enquiry, initiative and inventiveness.
5. Develop an understanding of the scientific skills essential for both further study and everyday life.
6. Plan, design and perform experiments to test theories and hypotheses.
7. Be proficient in the use of a range of scientific methods and techniques and in handling apparatus.

8. Develop the ability to work independently and collaboratively with others when necessary.
9. Integrate Information and Communication Technology (ICT) tools and skills.

Important Skills:

The Chemistry Curriculum framework aims to enable students to achieve academic success in science while equipping them with the skills needed to develop scientific thinking. It prepares them to pursue further studies and to participate effectively in a knowledge-based society, regardless of their future academic or career pathways.

- **Scientific enquiry skills:** Scientific enquiry, which ensures the development of scientific skills, intellectual and practical, should be integrated in the learning of the scientific content across all the science branches. Scientific enquiry skills include the following:

1. Carry out the practical experiments to develop the practical skills which will be mentioned in details below.
2. Find secondary information sources such as the resources available in the public libraries and on the Internet and use these after validations and making sure of the suitability of the subject.
3. Apply scientific knowledge and procedures to the situations of the reality Life.
4. Recognize the importance of cooperative teamwork, put work plans, distributes responsibilities, and regulates and sets specific targets for work.

- **Know how scientists are working:**

1. Realize that with science we can bring great benefits to humanity also if it is abused can cause serious damage to the environment.
2. Know how scientists are carrying out their work, such as environmental monitoring and control of industrial processes.
3. Know how scientists publish and present their ideas and results to encourage debate and development.
4. Know that science could lead to the emergence of ethical considerations and discuss them.

5. Know that there are many questions and considerations that cannot be answered by science.
6. Trace the historical development of some key scientific models and knows what contributions Scientists presented in this development.

- **Processing and delivery of information**

1. Present qualitative and quantitative data using a variety of methods, such as descriptive texts, graphics, images, tables, and maps with the use of technology methods and computer when it is appropriate, then analyse and explain these date to extract conclusions from them.
2. Use mathematical relationships routinely to calculate the quantities.
3. Do calculations based on data taken from the graphs and distinguishes between independent and dependent variables.
4. Handle data and writes reports about the results.
5. Use symbolic equations to represent chemical reactions and simple physical relationships.
6. Use the appropriate methods to deliver scientific information.

- **ICT application:**

This curriculum framework provides students with a wide range of opportunities to use ICT in their study of science in order to play a full part in modern society, students need to be confident and effective users of ICT. Opportunities for ICT include:

1. Gathering reliable information from the internet resources,
2. Using spreadsheets and other software to process data.
3. Using animations and simulations to visualize scientific ideas.
4. Using software to present ideas and information on paper and on screen.
5. Using distance learning programs and platforms.

Skills and abilities to be assessed:

Students' learning is assessed based on the assessment objectives outlined in the Student Assessment Handbook for Science (Grades 11–12) for Private Schools, issued by the Directorate General of Educational Assessment. The handbook is circulated through the official correspondence system and is also available on the Educational Portal (www.moe.gov.om). It should be consulted when planning and implementing assessment practices in science subjects at this level (Grades 11-12).

Chemistry Syllabus

The chemistry syllabus allows students to work individually and with others in practical, field and interactive activities that are related to theoretical concepts. It is expected that students will apply investigative and problem-solving skills, effectively communicate scientific information and appreciate the contribution that a study of chemistry makes to their understanding of the world. The syllabus places greater emphasis on the understanding and application of chemical concepts and principles and different learning styles and needs, so that students will develop skills that will be of long term value in an increasingly technological world, rather than focusing on large quantities of factual information. Through the principles of chemistry, students will understand everyday life, nature and technology, and the significance of the well-being of man and the environment.

Aims: Chemistry syllabus enables students to:

1. Appreciate and understand natural phenomena and the ways in which materials behave.
2. Be aware of the power, impact, and influence which Chemistry has in a modern scientific world and to emphasize that there is a responsibility that Chemistry be used for the good of the society and for the preservation of the environment.
3. Appreciate, understand, and use methods of science.
4. See the relevance of Chemistry to everyday life.

5. Appreciate and understand the role of Chemistry in enabling materials to be used in the service of mankind.
6. Understand basic chemical concepts in sufficient depth to provide an adequate foundation for specialization.
7. Develop the spirit of inquiry and to continue the search for new ways in which materials may be used in the service of mankind.
8. Make use of chemical data, concepts, principles, and terminology in communicating chemical information.

How to use this syllabus

This syllabus is arranged according to the following manner:

- **Outcomes:**

Indicate the scope of the content, including practical work which will be examined as well. However, practical work should not necessarily be limited to these objectives.

The numbering key: [Unit – Topic –Learning outcome]

e.g. Unit 1. (1. Atoms, molecules, and stoichiometry); Topic 1 (1.1 Relative masses of atoms and molecules); and a) is the first learning outcome (a) Define and use the terms relative atomic, isotopic, molecular and formula masses, based on the 12C scale.).

Note that teachers must have both textbooks and should rely on both textbooks to cover the learning objectives.

- **Practical experiments and activities:**

Show some examples of active learning activities and do not represent full scale activities that can be done. It is recommended that all of the suggested laboratory-related activities, such as conducting experiments must be done. Other activities like making field trips and viewing audio-visual materials, can be done also. Take into account the sufficient time to carry out the practical experiments determined in this syllabus and train students in practical skills related to them. The teachers should get benefit from the student text books, teacher's resources, practical workbooks and the interactive digital resources, that are recommended by MOE in the approved books list. The teachers should include the practical lessons in the semester plan.

Resources for teachers to upgrade their knowledge and skills

The main resources for the teachers are the text book, the practical workbook and the teacher's guides. The two recommended teacher's guides in the approved books list (teacher's resources pack) from Hodder Education and teacher's digital resources from Cambridge provide the needed support for the teachers. They include the following:

1) Teaching guide for each chapter includes teaching plan for the chapter with resources available for each topic in the chapter, introduction about the topic, topic summary, suggested teaching methods, key terms, common misunderstandings and misconceptions, methods for supporting struggling students, methods for challenging high achievers, homework suggestions and suggested activities and practical.
2) Answers to examination style questions (end-of-chapter questions).
3) Extra activities.
4) Homework with answer scheme.
5) Practical guidance.
6) Suggested websites.
7) Revision checklist.
8) Interactive tests.

9) Copies of diagrams and tables from text book.

10) Useful appendix.

Furthermore, teachers can make use of other publications that serves this syllabus greatly and can be found in Cambridge Education website:

https://www.cambridgeinternational.org/programmes-and-qualifications/cambridge-international-as-and-a-level-chemistry-9701/published-resources/

Some other resources as websites are listed in this syllabus can provide support for teachers for this syllabus. The range of resources covers a large area of this syllabus so it is well worth exploring these sites before the course starts to discover relevant resources that can be used or recommended to students when appropriate.

Grade 11 (Bilingual) Chemistry - Learning outcomes

SEMESTER ONE

Physical chemistry			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
1. **Atoms, molecules and stoichiometry**			
1.1 Relative masses of atoms and molecules	a) Define and use the terms relative atomic, isotopic, molecular and formula masses, based on the 12C scale.		1
1.2 Hydrated and anhydrous compounds	a) Understand and use the terms anhydrous, hydrated and water of crystallization.		1
1.3 The mole and the Avogadro constant	a) Define and use the term mole in terms of the Avogadro constant.		1
1.4 The calculation of empirical and molecular formulae	a) Define and use the terms empirical and molecular formula. b) Calculate empirical and molecular formulae, using combustion data or composition by mass.	**Practical 1:** Empirical formula of hydrated copper sulfate **(Chemistry for Cambridge international As & A level, Practical Workbook, page 1)**	5

1.5 Reacting masses and volumes (of solutions and gases)	a) Write and construct balanced equations. b) Perform calculations, including use of the mole concept, involving: i. reacting masses (from formulae and equations). ii. volumes of gases (e.g. in the burning of hydrocarbons) iii. volumes and concentrations of solutions. iv. limiting reagent and excess reagent. c) Deduce stoichiometric relationships from calculations such as those in 1.4(b).	**Practical 2**: Percentage composition of a mixture of sodium hydrogencarbonate and sodium chloride (**Chemistry for Cambridge international As & A level, Practical Workbook, page 11)**	9
2. Atomic structure			
2.1 Particles in the atom and atomic radius	a) Understand that atoms are mostly empty space surrounding a very small, dense. nucleus that contains protons and neutrons; electrons are found in shells in the empty space around the nucleus. b) Identify and describe protons, neutrons and electrons in terms of their relative charges and relative masses. c) Describe the behaviour of beams of protons, neutrons and electrons moving at the same velocity in an electric field. d) Deduce the numbers of protons, neutrons and electrons present in both atoms and ions given proton and nucleon numbers and charge.		2

	e) State and explain qualitatively the variations in atomic radius and ionic radius across a period and down a group.		
2.2 Electrons, energy levels and atomic orbitals	a) Understand the terms: • shells, sub-shells and orbitals • principal quantum number (n) • ground state, limited to electronic configuration b) Describe the number of orbitals making up s, p and d sub-shells, and the number of electrons that can fill s, p and d sub-shells. c) Describe and sketch the shapes of *s* and *p* orbitals. d) Describe the order of increasing energy of the sub-shells within the first three shells and the 4s and 4p sub-shells. e) Determine the electronic configuration of atoms and ions given the atomic or proton number and charge, using either of the following conventions: e.g. for Fe: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$ (full electronic configuration) or [Ar] $3d^6\ 4s^2$ (shorthand electronic configuration) f) Understand and use the electrons in boxes notation: e.g. for Fe: [Ar] 		13

2.3 Ionisation energy	g) Explain and use the term ionization energy. h) Construct equations to represent first, second and subsequent ionization energies. i) Identify and Explain the trends in ionization energies across a period and down a group of the Periodic Table. j) Identify and explain the variation in successive ionization energies of an element. k) Understand that ionization energies are due to the attraction between the nucleus and the outer electron. l) Explain the factors influencing the ionization energies of elements in terms of nuclear charge, atomic/ionic radius, shielding by inner shells and sub-shells and spin-pair repulsion. m) Deduce the electronic configurations of elements from successive ionization energy data. n) Interpret successive ionization energy data of an element in terms of the position of that element within the Periodic Table.		
3. **Chemical Bonding**			
3.1 Covalent bonding and coordinate (dative covalent) bonding	a) Define covalent bonding as electrostatic attraction between the nuclei of two atoms and a shared pair of electrons. b) Describe covalent bonding in molecules such as N_2, H_2, O_2, C_2, HCl, NH_3, CH_4, C_2H_4, C_2H_6, and CO_2. Use dot-and-cross diagrams to show the electronic configurations in these and similar molecules. c) Understand that elements in period 3 can expand their octet including in the compounds sulfur dioxide, SO_2, phosphorus pentachloride, PCl_5 , and sulfur hexafluoride, SF_6.	**Practical 3**: Physical properties of three different types of chemical structure (**Chemistry for Cambridge international As**	11

	d) Describe coordinate (dative covalent) bonding, including in the reaction between ammonia and hydrogen chloride gases to form the ammonium ion, NH^{4+} , and in the Al_2Cl_6 molecule. e) Describe covalent bonds in terms of orbital overlap giving σ and π bonds: i. σ bonds are formed by direct overlap of orbitals between the bonding atoms ii. π bonds are formed by the sideways overlap of adjacent p orbitals above and below the σ bond f) Describe how the σ and π bonds form in molecules including H_2, C_2H_6, C_2H_4, HCN and N_2. g) Use the concept of hybridization to describe sp, sp_2 and sp_3 orbitals. h) define the terms: i. bond energy as the energy required to break one mole of a particular covalent bond in the gaseous state ii. bond length as the internuclear distance of two covalently bonded atoms	**& A level, Practical Workbook, page 19)**	
3.2 Shapes of molecules, Intermolecular forces, and electronegativity	a) Explain the shapes and bond angles in molecules using model of electron-pair repulsion (including lone pairs) using simple example: BF_3, CO_2, CH_4, NH_3, H_2O, SF_6, PF_5. b) Describe hydrogen bonding using ammonia, hydrogen fluoride and water and its importance to the physical properties of substances. c) Describe intermolecular forces based on permanent and induced dipoles. d) Define electronegativity as the power of an atom to attract electrons to itself. e) Explain the factors influencing the electronegativities of the elements in terms of nuclear charge, atomic radius and shielding by inner shells and sub-shells.		

	f) State and explain the trends in electronegativity across a period and down a group of the Periodic Table. g) Use the concept of electronegativity to explain bond polarity and dipole moments of molecules.		
4. Reaction kinetics			
4.1 Rate of reaction	a) Explain and use the term rate of reaction, frequency of collisions, effective collisions and non-effective collisions. b) Explain qualitatively, in terms of frequency of effective collisions, the effect of concentration and pressure changes on the rate of a reaction. c) Use experimental data to calculate the rate of a reaction.	**Practical 4**: Effect of concentration on rate of chemical reaction (**Chemistry for Cambridge international As & A level, Practical Workbook, page 73)**	3

4.2 Effect of temperature on reaction rates and the concept of activation energy	a) Define activation energy, EA, as the minimum energy required for a collision to be effective. b) Sketch and use the Boltzmann distribution to explain the significance of activation energy. c) Explain qualitatively, in terms both of the Boltzmann distribution and of frequency of effective collisions, the effect of temperature change on the rate of a reaction.		4
4.3 The effect of catalysts	a) Explain and use the terms catalyst and catalysis: i. explain that, in the presence of a catalyst, a reaction has a different mechanism, i.e. one of lower activation energy ii. explain this catalytic effect in terms of the Boltzmann distribution b) Construct and interpret a reaction pathway diagram, for a reaction in the presence and absence of an effective catalyst.		4
5. **Introduction to organic chemistry**			
5.1 Formulae, functional groups and the naming of organic compounds	a) Interpret and use the general, structural, displayed and skeletal formulae of the following classes of compound (including cyclo compounds for i and ii): i. Alkanes and alkenes ii. Halogenoalkanes iii. Alcohols (including primary, secondary and tertiary). iv. Aldehydes and ketones v. Carboxylic acids and esters		8

	vi. Amines (primary only), and nitriles b) Understand and use systematic nomenclature of simple aliphatic organic molecules with functional groups detailed in this syllabus up to six carbon atoms. c) Deduce the molecular formula of a compound, given its structural, displayed or skeletal formula. d) Describe and explain the shape of, and bond angles in, molecules containing sp, sp2 and sp3 hybridized atoms. e) Describe the arrangement of σ and π bonds in molecules containing sp, sp2 and sp3 hybridized atoms. f) Understand and use the term planar when describing the arrangement of atoms in organic molecules, for example ethane. g) Interpret and use the following terminology associated with types of organic compounds and reactions: i. nucleophile, electrophile, nucleophilic, electrophilic ii. addition, substitution, elimination, hydrolysis, condensation iii. oxidation and reduction		
5.2 Isomerism: structural and stereoisomerism	a) Describe structural isomerism and its division into chain, positional and functional group isomerism *exclusively ester and carboxylic acid and aldehyde and ketone)*. b) Describe stereoisomerism and its division into geometrical (cis-trans) and optical isomerism. c) Describe geometrical (cis/trans) isomerism in alkenes, and explain its origin in terms of restricted rotation due to the presence of π bonds. d) Explain what is meant by a chiral center and that such a center gives rise to two optical isomers (enantiomers).		7

	(Candidates should appreciate that compounds can contain more than one chiral center, but knowledge of meso compounds, or nomenclature such as diastereoisomers is not required) e) Identify chiral centers and geometrical (cis/trans) isomerism in a molecule of given structural formula including cyclic compounds. f) Deduce the possible isomers for an organic molecule of known molecular formula.		
5.3 Hydrocarbons	a) Recall the reactions (reagents and conditions) by which alkanes can be produced: i. addition of hydrogen to an alkene in a hydrogenation reaction, $H_2(g)$ and Pt/Ni catalyst and heat ii. cracking of a longer chain alkane, heat with Al_2O_3 b) Describe: i. the complete and incomplete combustion of alkanes ii. the free-radical substitution of alkanes by Cl_2 or Br_2 in the presence of ultraviolet light, as exemplified by the reactions of ethane c) Describe the mechanism of free-radical substitution with reference to the initiation, propagation and termination steps. d) Understand the general unreactivity of alkanes, including towards polar reagents in terms of the strength of the C–H bonds and their relative lack of polarity. e) Recall the reactions (including reagents and conditions) by which alkenes can be produced:		6

	i. elimination of HX from a halogenoalkane by ethanolic NaOH and heat ii. dehydration of an alcohol, by using a heated catalyst (e.g. Al_2O_3) or a concentrated acid. iii. cracking of a longer chain alkane. f) Describe the chemistry of alkenes as exemplified, where relevant, by the following reactions of ethene and propene (including the Markovnikov's addition of asymmetric electrophiles to alkenes using propene as an example): i. addition of hydrogen, steam, hydrogen halides and halogens. ii. oxidation by cold dilute acidified manganate (VII) ions to form the diols. g) Explain the mechanism of addition of bromine to ethene.		

Grade 11 (Bilingual) Chemistry – Learning outcomes SEMESTER TWO			
Physical chemistry			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
6. Halogenoalkanes and Alcohols compounds			
6.1 Halogenoalkanes	a) Interpret and use the general, structural, displayed and skeletal formulae of halogenoalkanes. b) Understand and use systematic nomenclature of simple aliphatic halogenoalkanes up to six carbon atoms. c) Recall the reactions (reagents and conditions) by which halogenoalkanes can be produced: i. the free-radical substitution of alkanes by Cl_2 or Br_2 in the presence of ultraviolet light, as exemplified by the reactions of ethane ii. electrophilic addition of an alkene with a halogen, X_2, or hydrogen halide, HX(g), at room temperature iii. substitution of an alcohol, e.g. by reaction with HX or KBr with H_2SO_4 or H_3PO_4; or with PCl_3 and heat; or with PCl_5; or with $SOCl_2$ d) Classify halogenoalkanes into primary, secondary and tertiary e) Describe the following nucleophilic substitution reactions: i. the reaction with NaOH(aq) and heat to produce an alcohol ii. the reaction with KCN in ethanol and heat to produce a nitrile iii. the reaction with NH_3 in ethanol heated under pressure to produce an amine	**Practical 5**: How a halogenoalkane structure affects the rate of hydrolysis **(Chemistry for Cambridge international As & A level, Practical Workbook, page 112) (optional)**	6

	iv. the reaction with aqueous silver nitrate in ethanol as a method of identifying the halogen present as exemplified by bromoethane		
6.2 Alcohols	a) Interpret and use the general, structural, displayed and skeletal formulae of alcohols. b) Understand and use systematic nomenclature of simple aliphatic alcohols up to six carbon atoms. c) Draw and classify alcohols into primary, secondary and tertiary d) Describe the reactions (reagents and conditions) by which alcohols can be produced: i. electrophilic addition of steam to an alkene, $H_2O(g)$ and H_3PO_4 catalyst ii. reaction of alkenes with cold dilute acidified potassium manganate(VII) to form a diol iii. substitution of a halogenoalkane using NaOH(aq) and heat iv. reduction of an aldehyde or ketone using $NaBH_4$ or $LiAlH_4$ v. reduction of a carboxylic acid using $LiAlH_4$ e) Describe: i. the reaction of alcohols with oxygen (combustion) ii. substitution of alcohols to form halogenoalkanes, e.g. by reaction with HX or KBr with H_2SO_4 or H_3PO_4; or with PCl_3 and heat; or with PCl_5; or with $SOCl_2$ iii. dehydration of alcohols to an alkene, by using a heated catalyst, e.g. Al_2O_3 or a concentrated acid.		8
7. carbonyl compounds			
7.1 Aldehydes and Ketones	a) Interpret and use the general, structural, displayed and skeletal formulae of Aldehydes and Ketones.	**Practical 6**: Part 2 (**just part a &b**): Investigating compounds that do	9

	b) Understand and use systematic nomenclature of simple aliphatic Aldehydes and Ketones up to six carbon atoms. c) Describe: i. the formation of aldehydes and ketones from primary and secondary Alcohols respectively using $Cr_2O_7^{2-}/H^+$. ii. the reduction of aldehydes and ketones, e.g., using $NaBH_4$ or $LiAlH_4$. iii. the reaction of aldehydes and ketones with HCN and NaCN. d) Describe the mechanism of the nucleophilic addition reactions of hydrogen cyanide with aldehydes and ketones. e) Distinguish between aldehyde and ketone by using Fehling's and Tollens' reagents. f) Describe the reaction of CH_3CO^- compounds with alkaline aqueous iodine to give tri-iodomethane.	contain a hydroxyl group Part 3 (**just part b**): Identifying compounds that do not contain the hydroxyl group **(Chemistry for Cambridge international As & A level, Practical Workbook, page 117)**	
7.2 Carboxylic acids	a) Interpret and use the general, structural, displayed and skeletal formulae of Carboxylic acids. b) Understand and use systematic nomenclature of simple aliphatic Carboxylic acids up to six carbon atoms. c) Describe the reactions by which carboxylic acids can be produced: i. oxidation of primary alcohols and aldehydes with acidified $K_2Cr_2O_7$ or acidified $KMnO_4$ and refluxing ii. hydrolysis of nitriles with dilute acid or dilute alkali followed by acidification iii. hydrolysis of esters with dilute acid or dilute alkali and heat followed by acidification) d) Describe: i. the redox reaction of Carboxylic acids with reactive metals to produce a salt and $H_2(g)$ ii. the neutralisation reaction of Carboxylic acids with alkalis to produce a salt and $H_2O(l)$		8

	iii. the acid–base reaction of Carboxylic acids with carbonates to produce a salt and $H_2O(l)$ and $CO_2(g)$ iv. esterification of Carboxylic acids with alcohols with concentrated H_2SO_4 as catalyst v. reduction of Carboxylic acids by $LiAlH_4$ to form a primary alcohol		
8. Equilibria			
8.1 Chemical equilibria: reversible reactions; dynamic equilibrium	a) Explain, in terms of rates of the forward and reverse reactions, what is meant by a reversible reaction and dynamic equilibrium. b) Understand the need for a closed system in order to establish dynamic equilibrium. c) State Le Chatelier's principle and apply it to deduce qualitatively (from appropriate information) the effects of changes in temperature, concentration or pressure on a system at equilibrium. d) State whether changes in temperature, concentration or pressure or the presence of a catalyst affect the value of the equilibrium constant for a reaction. e) Deduce expressions for equilibrium constants in terms of concentrations, K_c, and partial pressures, K_p (***use of mole fraction and the relationship between Kp and K_c is not required)***. f) Calculate the values of equilibrium constants in terms of concentrations or partial pressures from appropriate data. g) Calculate the quantities present at equilibrium, given appropriate data (such calculations will not require the solving of quadratic equations). h) Describe and explain the conditions used in the Haber process and the contact process, as examples of the importance of an understanding of chemical equilibrium in the chemical industry.	**Practical 7**: Change in PH during an acid-base titration **(Chemistry for Cambridge international As & A level, Practical Workbook, page 163)**	16

8.2 Brønsted–Lowry theory of acids and bases	a) State the names and formulae of the common acids, limited to hydrochloric acid, HCl, sulfuric acid, H_2SO_4, nitric acid, HNO_3,and ethanoic acid, CH_3COOH. b) State the names and formulae of the common alkalis, limited to sodium hydroxide, NaOH, potassium hydroxide, KOH, ammonia, NH_3. c) Describe the Brønsted–Lowry theory of acids and bases. d) Describe strong acids and strong bases as fully dissociated in aqueous solution and weak acids and weak bases as partially dissociated in aqueous solution. e) Appreciate that water has pH of 7, acid solutions pH of below 7 and alkaline solutions pH of above 7. f) Explain qualitatively the differences in behaviour between strong and weak acids including the reaction with a reactive metal and difference in pH values by use of a pH meter, universal indicator or conductivity g) Understand that salts are formed in neutralisation reactions h) Sketch the pH titration curves of titrations using combinations of strong and weak acids with strong and weak alkalis i) Finding the concentration of acid or base by titration (limited on a monoprotic acid and base using the equation C_1V_1 (acid) = C_2V_2 (base)) .		11
9. Enthalpy Changes			
9.1 Enthalpy change, ΔH	a) Understand that chemical reactions are accompanied by enthalpy changes and these changes can be exothermic (ΔH is negative) or endothermic (ΔH is positive). b) Construct and interpret a reaction pathway diagram, in terms of the enthalpy change of the reaction and of the activation energy.	**Practical 8**: Enthalpy change of combustion of alcohols **(Chemistry for Cambridge**	12

	c) Define and use the terms: i. standard conditions (this syllabus assumes that these are 298K and 101 kPa) shown by $\ominus$. ii. enthalpy change with particular reference to: reaction, ΔH_r , formation, ΔH_f , combustion, ΔH_c , neutralisation, ΔH_{neut} d) Understand that energy transfers occur during chemical reactions because of the breaking and making of chemical bonds. e) Use bond energies (ΔH positive, i.e. bond breaking) to calculate enthalpy change of reaction, ΔH_r. f) Understand that some bond energies are exact and some bond energies are averages. g) Calculate enthalpy changes from appropriate experimental results, including the use of the relationships $q = mc\Delta T$ and $\Delta H = -mc\Delta T/n$.	**international As & A level, Practical Workbook, page 34)**	
9.2 Hess's Law	a) State the Hess's law. b) Apply Hess's Law to construct simple energy cycles. c) Carry out calculations using cycles and relevant energy terms, including: i. determining enthalpy changes that cannot be found by direct experiment ii. use of bond energy data	**Practical 9**: Enthalpy change of thermal decomposition **(Chemistry for Cambridge international As & A level, Practical Workbook, page 40)**	10

Yearly plan for grade 11

	Grade 11– semester one		Grade 11– semester two
1	Atoms, molecules and stoichiometry	6	Halogen and Alcohol compounds
2	Atomic structure	7	Carbonyl compounds
3	Chemical Bonding	8	Equilibria
4	Reaction kinetics	9	Enthalpy changes
5	Introduction to organic chemistry		

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER ONE			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
Physical Chemistry			
1. Quantitative Equilibria			
1.1 Acids and bases	a) Understand and use the terms conjugate acid and conjugate base. b) Define conjugate acid–base pairs, identifying such pairs in reactions. c) Define mathematically the terms pH, K_a , pK_a and K_w and use them in calculations. d) Calculate [H^+ (aq)] and pH values for: (limited on a monoprotic acid and base) i. strong acids ii. strong alkalis iii. weak acids e) Define a buffer solution. f) Explain how a buffer solution can be made. g) Explain how buffer solutions control pH, use chemical equations in these explanations. h) Describe and explain the uses of buffer solutions, including the role of HCO_3^- in controlling pH in blood. i) Calculate the pH of buffer solutions from given appropriate data (acidic buffer only). **(Note: You can use Henderson – Hasselbalch equations.)**	**Practical 1** Making a buffer solution **(Chemistry for Cambridge international As & A level, Coursebook, page 451)**	18

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER ONE			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
	j) Calculate the change in the pH of buffer solution upon the addition of small amount of strong acid into the buffer. k) Understand and use the term solubility product, K_{sp} **(Note: the equilibrium equation with states are required)** l) Write an expression for K_{sp}. m) Work out the K_{sp} unit. n) Calculate K_{sp} from concentrations and vice versa. o) Understand and use the common ion effect to explain the different solubility of a compound in a solution containing a common ion. p) Perform calculations using K_{sp} values and concentration of a common ion. q) Predict the formation of precipitate from the K_{sp} value.		
Physical Chemistry			
2.Electrochemistry			
2.1 Voltaic cell (Galvanic cell)	a) Explain the redox reactions showing the transfer of electrons from the reducing agent to the oxidizing agent. b) Define the terms: i. standard electrode potential ii. standard cell potential	**Practical 2** Comparing the voltage of electrochemical cells	15

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER ONE			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
	c) Draw, label and state the functions of the following in the electrochemical cell: i. oxidizing agent ii. reducing agent iii. the electrolyte in each solution iv. the salt bridge v. the electrodes vi. the wire vii. the voltmeter d) Describe the standard hydrogen electrode. e) State the standard conditions to make the standard half-cell. f) Describe methods used to measure the standard electrode potentials of: i. metals or non-metals in contact with their ions in aqueous solution ii. ions of the same element in different oxidation states g) Calculate a standard cell potential by combining two standard electrode potentials. **[Use the appendix no.1]**	**(Chemistry for Cambridge international As & A level, Practical Workbook, page 150)**	

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER ONE			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
	h) Use standard cell potentials to: i. deduce the polarity of each electrode and hence explain/deduce the direction of electron flow in the external circuit of a simple cell ii. deduce the oxidizing and reducing agents. iii. predict the feasibility of a reaction. i) Deduce from E^{Θ} values the relative reactivity of elements, compounds and ions as oxidising agents or as reducing agents. j) Construct redox equations using the relevant half-equations. k) Predict qualitatively how the value of an electrode potential, E, varies with the concentrations of the aqueous ions. l) Use the Nernst equation, e.g. $E = E^{\Theta} + \left(\frac{0.059}{z}\right) log \frac{[oxidised\ species]}{[reduced\ species]}$ to predict quantitatively how the value of an electrode potential varies with the concentrations of the aqueous ions.		
2.2 Electrolysis	a) Draw and label an electrolytic cell showing the followings: i. electrolyte ii. electrods (positive electrode (anode), negative electrode (cathode) iii. power supply	**Practical 3** Finding the charge on 1 mole of electrons	11

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER ONE			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
	b) Predict the identities of substances liberated during electrolysis from the state of **(Note: electrodes are inert) :** i. electrolyte (molten or aqueous). ii. position in the redox series (electrode potential). iii. concentration of the ions in the electrolyte. **(Note: For a concentrated and diluted aqueous solution students are assessed only on compounds that has SO_4^{2-}, OH^- or Cl^-).** **c) Calculate:** i. the quantity of charge passed during electrolysis, using Q = It . ii. the mass of substance liberated during electrolysis. iii. the volume of substance liberated during electrolysis.	**(Chemistry for Cambridge international As & A level, coursebook, page 409)**	
Physical Chemistry			
3.Lattice energy			
3.1 Lattice energy	a) Define and use the terms: i. enthalpy change of atomization, ΔH_{at}. ii. lattice energy, ΔH_{latt} (the change from gas phase ions to solid lattice). b) Define and use the terms first electron affinity, EA and ionization energy, IE.		9

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER ONE			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
	c) Explain the factors affecting the electron affinities of elements. d) Describe and explain the trends in the electron affinities of the Group 16 and Group 17 elements. e) Construct and use Born–Haber cycles for ionic solids (limited to $^{+}1$ and $^{+}2$ cations, $^{-}1$ and $^{-}2$ anions). f) Carry out calculations involving Born–Haber cycles. g) Explain, in qualitative terms, the effect of ionic charge and of ionic radius on the numerical magnitude of a lattice energy.		
3.2 Enthalpies of solution and hydration	a) Define and use the term enthalpy change with reference to hydration, ΔH_{hyd}, and solution, ΔH_{sol} . b) Construct and use an energy cycle/energy level involving enthalpy change of solution, lattice energy and enthalpy change of hydration. c) Carry out calculations involving the energy cycles/energy level in **3.2.b**. d) Explain, in qualitative terms, the effect of ionic charge and of ionic radius on the numerical magnitude of an enthalpy change of hydration.	**Practical 4** Enthalpy change of solution of chlorides (**Chemistry for Cambridge international As & A level, Practical Workbook, page 131)**	8

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER ONE			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
Organic Chemistry			
4. Nitrogen compounds			
4.1 Primary, secondary and tertiary amines	a) Classify amines to primary, secondary and tertiary using the general, structural, displayed and skeletal formulae. b) Understand, use and draw systematic nomenclature of primary, secondary and tertiary amines. **(Note: For secondary and tertiary amines students are assessed only on amines with identical substituents)** c) Recall the reactions (reagents and conditions) by which primary and secondary amines are produced: i. reaction of halogenoalkanes with NH_3 in ethanol heated under pressure. ii. reaction of halogenoalkanes with primary amines in ethanol, heated in a sealed tube /under pressure. iii. the reduction of amides with $LiAlH_4$. iv. the reduction of nitriles with $LiAlH_4$ or H_2 /Ni. d) Describe the condensation reaction of ammonia or an amine with an acyl chloride at room temperature to give an amide.		5

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER ONE			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
	e) Describe and explain the relative basicities of ammonia, primary amines, and secondary amines with similar alkyl groups. **[Note: no need to discuss the basicity of tertiary amines]**		
4.2 Amides	a) Understand, use and draw systematic nomenclature of primary amides. b) Recall the reactions (reagents and conditions) by which amides are produced: i. the reaction between ammonia and an acyl chloride at room temperature. ii. the reaction between a primary amine and an acyl chloride at room temperature. c) Describe the reactions of amides: i. hydrolysis with aqueous alkali or aqueous acid. ii. the reduction of the CO group in amides with $LiAlH_4$ to form an amine. d) State and explain why amides are much weaker bases than amines.		4

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER ONE			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
4.3 Amino acids	a) Identify the structure of an amino acid and state that it contains both an amino group and a carboxyl group attached to the same carbon atom. b) Describe the acid/base properties of amino acids and the formation of zwitterions, including the isoelectic point. **[Note: The student will not be assessed about electrophoresis]** c) Describe and draw the formation of amide (peptide) bonds between amino acids to give di- and tripeptides.		5

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER TWO			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
Inorganic Chemistry			
5.Chemistry of transition elements			
5.1 General physical and chemical properties of the first row of transition elements, titanium to copper	a) Define a transition element as a d-block element which forms one or more stable ions with incomplete d orbitals. b) Understand that transition elements have the following properties: i. they have variable oxidation states ii. they behave as catalysts iii. they form complex ions iv. they form colored compounds c) State the electronic configuration of each of the first row of transition elements and of their ions. d) Explain why Sc and Zn are not transitional elements. e) Explain why transition elements have variable oxidation states in terms of the similarity in energy of the 3d and the 4s sub-shells. f) Explain why transition elements form complex ions in terms of vacant d orbitals that are energetically accessible.	**Practical 5** Iorn tablets (**Chemistry for Cambridge international As & A level, Practical Workbook, page 198)** **<u>Optional</u>**	9

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER TWO			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
5.2 General characteristic chemical properties of the first set of transition elements, titanium to copper	a) Define the term ligand as a species that contains a lone pair of electrons that forms a dative covalent bond to a central metal atom/ion. b) Understand and use the terms: i. monodentate ligand including as examples H_2O, NH_3, Cl^- and CN^- ii. bidentate ligand including as examples 1,2-diaminoethane (***en***, $H_2NCH_2CH_2NH_2$) and the ethanedioate ion (***ox,*** $C_2O_4^{2-}$) iii. polydentate ligand including as an example ($EDTA^{4-}$, $(CH_2N(CH_2COO)_2)_2^{-4}$) c) Define the term complex as a molecule or ion formed by a central metal atom/ion surrounded by one or more ligands. d) Describe the geometry of transition element complexes which are linear, square planar, tetrahedral or octahedral. e) Draw the shapes of complex ions with 2,4 and 6 coordination numbers. **-The drawing of 3D is requuired** **-The drawing of $EDTA^{4-}$ complexs is not required** **[Note for e and f outcomes: Students are assessed on square planar and tetrahedral geometries based solely on the examples provided in the Cambridge and Hooder textbooks]** f) Describe and draw the types of geometrical (cis-trans) isomerism shown only by complex ions (Pt^{2+} and Ni^{2+}).	**Practical 6** Precipitation of hydroxides of Copper (II), iron(II), and iron(III) **[use appendix no.2]**	9

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER TWO			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
	g) State what is meant by coordination number. h) Predict the formula and charge of a complex ion, given the metal ion, its charge or oxidation state, the ligand and its coordination number or geometry. i) Describe and explain the reactions of transition elements with ligands to form complexes, including the complexes of copper(II) and cobalt(II) ions with water, ammonia molecules, hydroxide and chloride ions. **[Note: The student will not be assessed about colour change of solutions]**	**Practical 7** Complexes and ligand exchange **[use annex no.2]**	
5.3 Colour of complexes	a) Define and use the terms degenerate and non-degenerate d orbitals. b) Sketch the shape of a $3d_{xy}$ orbital and $3d_z^2$ orbital. c) Describe the splitting of degenerate d orbitals into two non-degenerate sets of d orbitals of higher energy, and use of ΔE in: i. octahedral complexes, two higher and three lower d orbitals ii. tetrahedral complexes, three higher and two lower d orbitals d) Explain why transition elements form coloured compounds in terms of the frequency of light absorbed as an electron is promoted between two non-degenerate d orbitals.		5

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER TWO			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
Physical Chemistry			
6 **Quantitative Kinetics**			
6.1 Rate of reactions	a) Explain and use the terms rate equation, order of reaction, overall order of reaction, rate constant, and half-life. b) Understand and use rate equations of the form rate = k $[A]^m[B]^n$ (for which *m* and n are 0, 1 or 2). c) Deduce the order of a reaction from concentration-time graphs or from experimental data relating to the initial rates method and half-life method. d) Interpret experimental data in graphical form, including concentration-time and rate-concentration graphs. e) Calculate an initial rate using concentration data. f) Construct a rate equation. g) Work out the rate constant unit. h) Show understanding that the half-life of a first-order reaction is independent of concentration. i) Use the half-life of a first-order reaction in calculations. j) Calculate the numerical value of a rate constant, for example by: i. using the initial rates and the rate equation ii. using the half-life, $t_{1/2}$, and the equation $k = 0.693/t_{1/2}$ k) Describe qualitatively the effect of temperature change on the rate constant and hence the rate of a reaction.	**Practical 8** Kinetics of the reaction between propanone and iodine **(Chemistry for Cambridge international As & A level, Practical Workbook, page 181)** **optional**	16

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER TWO			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
6.2 Homogeneous and heterogeneous catalysts	a) Explain that catalysts can be homogeneous or heterogeneous. b) Describe the mode of action of a heterogeneous catalyst to include adsorption of reactants, bond weakening and desorption of products, for example: i. iron in the Haber process. ii. palladium, platinum and rhodium in the catalytic removal of oxides of nitrogen from the exhaust gases of car engines.		4
Physical Chemistry			
7 **Entropy and Gibbs free energy**			
7.1 Entropy Change, ΔS	a) Define the term entropy, S, as the number of possible arrangements of the particles and their energy in a given system. b) Predict and explain the sign of the entropy changes that occur: i. during a change in state, e.g. melting, boiling and dissolving (and their reverse). ii. during a temperature change. iii. during a reaction in which there is a change in the number of gaseous molecules. c) Calculate the entropy change for a reaction, ΔS, given the standard entropies, $S^{\ominus}$, of the reactants and products, $\Delta S^{\ominus} = \Sigma S^{\ominus}$ (products) – $\Sigma S^{\ominus}$ (reactants) **(use of $\Delta S^{\ominus} = \Delta S_{surr}^{\ominus} + \Delta S_{sys}^{\ominus}$ is not required)**		9

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER TWO			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
7.2 Gibbs free energy change, ΔG	a) State and use the Gibbs equation $\Delta G^{\ominus} = \Delta H^{\ominus} - T\Delta S^{\ominus}$. b) Perform calculations using the equation $\Delta G^{\ominus} = \Delta H^{\ominus} - T\Delta S^{\ominus}$. c) State whether a reaction or process will be feasible by using the sign of ΔG. d) Predict the effect of temperature change on the feasibility of a reaction, given standard enthalpy and entropy changes.		8
Organic chemistry			
8 Arenes and Phenols			
8.1 Arenes	a) Describe and explain the shape of benzene molecules, including sp^2 hybridization, in terms of σ bonds and a delocalized π system. b) Understand, use and draw systematic nomenclature of simple aromatic molecules with one benzene ring and one to three simple substituents (limited to the following substituents: -R, -X, -OH, $-NH_2$, -COOH and $-NO_2$ where R is an alkyl group and X is an halide group). c) Describe the chemistry of arenes as exemplified by the following reactions of benzene and methylbenzene: i. substitution reactions with Cl_2 and with Br_2 in the presence of a catalyst, $AlCl_3$ or $AlBr_3$, to form halogenoarenes (aryl halides).		12

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER TWO			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
	ii. nitration with a mixture of concentrated HNO_3 and concentrated H_2SO_4 at a temperature between 25°C and 60°C. iii. Friedel–Crafts alkylation using a mixture of RCl, $AlCl_3$ and heat (Note:R is alkyl group). iv. Friedel–Crafts acylation using a mixture of RCOCl, $AlCl_3$ and heat (Note:R is alkyl group. v. complete oxidation of the side-chain using hot alkaline $KMnO_4$ and then dilute acid to give a benzoic acid. vi. hydrogenation of the benzene ring using H_2 and Pt/Ni catalyst and heat to form a cyclohexane ring. d) Describe the mechanism of electrophilic substitution in the formation of bromobenzene and nitrobenzene only. e) Predict whether halogenation will occur in the side-chain or in the aromatic ring in arenes depending on reaction conditions. f) Describe that in the electrophilic substitution of arenes, different substituents direct to different ring positions (limited to the directing effects of $–NH_2$, –OH, –R, $–NO_2$, –COOH and –COR). (**See table 25.4 page 553 in Chemistry for Cambridge international As & A level, Coursebook)** g) Explain the difference in reactivity between a halogenoalkane and a a halogenoarene.		

Chemistry Grade 12 (Bilingual) - Learning outcomes SEMESTER TWO			
Topic	**Learning objectives**	**Practical activities**	**Number of lessons**
	h) Describe the preparation of phenylamine via the nitration of benzene to form nitrobenzene followed by reduction with hot Sn/concentrated HCl, followed by NaOH(aq). i) Describe the reaction of phenylamine with Br_2(aq) at room temperature. j) State and explain why the phenylamine is a weaker base than ammonia.		
8.2 Phenols	a) Describe the reactions (reagents and conditions) by which phenol can be produced: i. reaction of phenylamine with HNO_2 or $NaNO_2$ and dilute acid below 10°C to produce the diazonium salt; further warming of the diazonium salt with H_2O to give phenol. b) Recall the chemistry of phenol, as exemplified by the following reactions: i. with Na(s) to produce sodium phenoxide and H_2(g). ii. with bases, for example NaOH(aq) to produce sodium phenoxide. iii. bromination of the aromatic ring with Br_2(aq) to form 2,4,6-tribromophenol. v. nitration of the aromatic ring with dilute HNO_3(aq) at room temperature to give a mixture of 2-nitrophenol and 4-nitrophenol. c) Explain the acidity of phenol. d) Describe and explain the relative acidities of water, phenol and ethanol.	**Practical 9** Bromination of Phenol (**Chemistry for Cambridge international As & A level, Coursebook,** page 551 **(optional)**	8

Yearly plan for grade 12

	Grade 12– semester one		Grade 12– semester two
1	Quantitative Equilibria	5	Chemistry of transition elements
2	Electrochemistry	6	Reaction kinetics
3	Lattice energy	7	Entropy and Gibbs free energy
4	Nitrogen Compounds	8	Arenes and Phenols

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End Of Chemistry Syllabus